STUDY ON THE ECOLOGY OF WILD UNGULATES OF KEOLADEO NATIONAL PARK BHARATPUR, RAJASTHAN

THESIS SUBMITTED FOR THE DEGREE OF

Doctor of Philosophy

IN

WILDLIFE SCIENCE

BY

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CERTIFICATE

This is to certify that the dissertation "Study on the ecology of wild ungulates of Keoladeo National Park, Bharatpur, Rajasthan" submitted for the award of Ph.D degree in Wildlife Science, of the Aligarh Muslim University, Aligarh, is the original work of Mr. Md. Nayerul Haque. This work has been done by the candidate under my supervision.

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The work on "Study on the Ecology of Wild ungulates of Keoladeo National Park, Bharatpur, Rajasthan" has been done by Mr.Md.Nayerul Haque in Keoladeo National Park as a part of the Bharatpur Ecological Project under my supervision. All the data contained in the dissertation has been collected by Mr.Md.Nayerul Haque and has not yet been submitted for any degree elsewhere.

DR. V. S. VIJAYAN
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1. INTRODUCTION

India, in spite of fast depletion of wildlife during the present century, still has a remarkable variety of large mammals and the richness in species is exceeded by only a few countries of the world. The neglect of this invaluable resource during the period of colonial rule, in the single minded hurry to plunder the forest resources and unfortunately even after Independence, due to ignorance and government's preoccupation with post-Independence problems, has caused serious damage to our wildlife and its habitats.

Inspite of the realization that wildlife represents the country's fastest vanishing asset, during the first two decades of India's Independence no detailed studies of any kind had been attempted on the large mammals (Schaller 1967). That was the observation of an eminent wildlife biologist who undertook some pioneering studies on wildlife in India in 1965. Though the situation today is not that bad, we still do not know much has to be learnt for scientific management of wildlife. Some studies have been done on single species in one or the other region of the country but very few scientific studies (Berwick 1974 and Mishra 1982) have so far been done on all the ungulates species inhabiting one locality. The most fruitful approach from the stand point of conservation and management is to collect a broad spectrum of facts on all species of ungulates sharing a habitat because this provides a better understanding of their interrelationship.

In recent time there has been an increasing awareness of the importance of grazing and grazing animals in the dynamics of ecological system, and increasing interest in the role played by large herbivores in shaping and maintaining vegetational formations. Recent reviews which summarize the potential effects of heavy grazing upon vegetation are presented by Crawley (1983), Gessaman and MacMohan (1984) and Putman (1986). In India very few studies have been done on the impact of grazing on vegetation except some work by Pandey (1979, 1981). This is probably the first study on interaction between Feral cattle and wild ungulates, both of whom enjoy equal status.

The present study has been inspired by such ecological and management concerns and was focused on the ecology and behaviour of all species of hoofed animals of Keoladeo National Park. Most of the available information about these species in India and also of related species found in other parts of the world has been summarised.

In the context of a scientific management of ungulates and their habitat, it is quite pertinent to refer to competition theory. Lotka (1925) and Volterra (1926) separately developed mathematical equations to describe the relationship between two species competing for the same food resource. On the basis of Lotka-Volterra models and other evidences, one can conclude that if a species multiplies faster it may slow down the growth of population of the other competing species, which may be eased out of that habitat or may even become extinct. This line of thinking led to the evolution of Gause's principle, which rules out the coexistence in the same habitat, of two species with identical niches. Though Gause is usually credited with this idea, it was conceived much earlier by the ornithologist Joseph Grinnell (1904, 1917) and few others.

This concept has been recently modified into what is known as competitive exclusion principle (Hardin 1960) which can be summarised as follows: "Two competing species with identical ecological requirements can not occupy the same area". It is, however, possible that species may compete for some essential resource without being complete competitors and still co-exist in the same habitat. Limited niche overlap, therefore, does not necessarily lead to extinction of one or more species. If the concerned resource or resources are available in abundance, such as space and air, which are utilized by all species in every habitat, there is no likelihood of fierce competition between species, and no apprehension of extinction of species.

The above mentioned phenomena and facts have to be kept in view in management planning, to avoid trial and error method which is sometimes resorted to in the absence of baseline information and data. It is hoped that those concerned with conservation and management of wildlife and its habitats in general and of Keoladeo National Park in particular, will find this report useful and helpful. Further in-depth studies on related problems are called for. Similar studies in other protected areas are necessary.

The Keoladeo National Park was set up originally by Maharaja of Bharatpur some 250 years ago as a waterfowl refuge to be used as a hunting ground. The park has been hailed by the ornithologists as a paradise. Apart from 360 species of birds there as many other species of animals in the park. It contains seven species of ungulates, namely Chital (*Axis axis*), Sambar (*Cervus unicolor*), Blackbuck (*Antilope cervicapra*), Nilgai (*Boselaphus tragocamelus*), Feral cattle (*Bos indicus*), Wild boar (*Sus scrofa*) and a few Hog deer (*Axis porcinus*). Out of these seven species, three viz; the Blackbuck, Nilgai and Chital are not found outside the Indian sub-continent and Sambar is not found outside Asia. However, few Indian ungulates were introduced in Texas where they are thriving. Ables (1974) studied Chital (*Axis axis*), Mungal (1978) worked on Blackbuck (*Antilope cervicapra*) while Sheffield *et al.* (1983) studied Nilgai (*Boselphus tragocamelus*). All these studies were done in Texas.

A project was taken up by the Bombay Natural History Society to study the ecology of ungulates as a part of the long term studies on the ecosystem of the park.

1.1 Aims

Bharatpur is one of the World Heritage sites and is well known for its wetland. Till 1982, buffalo including domestic cattle were allowed to graze but soon after its declaration as a National Park, cattle grazing was stopped. As wetland plant communities are seral and not stable; control of the aquatic macrophytes and grasses is necessary for maintaining the system (Thomas 1982). Herbivore mammals and waterfowl~~s~~ play this key role in nature. Keeping the buffalo and domestic cattle out was, therefore, thought undesirable on ecological consideration.

Control of grass growth in the wetland in the absence of Buffalo was considered very difficult, if not altogether impossible. Mechanical devices like bulldozing were tried with very limited success and could not be a substitute for Buffalo and domestic cattle. Reliance on the existing population of Feral cattle for keeping the growth of macrophytes and grasses in the wetland does not appear to be a safe bet, and hence it was thought necessary to try to find the answer of two major problem (a) whether the present number of feral cattle can control the aquatic macrophytes and grasses? and (b) can the wild ungulate species co-exist with feral cattle in the park ?.

1.2 Objectives

This dissertation provides the basic ecological data on the consumers (ungulates) and thus attains importance in understanding the system which is necessary for conservation and management of an existing natural community. Interrelationship between species has been emphasised in this study and single species study has been avoided to the extent feasible. Following broad ecological objectives were set.

(a) To estimate the population of each ungulate species found in the park.

(b) To describe their patterns of habitat utilization.

(c) To study the time budget and activity pattern of each species.

(d) To determine the food habits and preference of each ungulate species.

(e) To evaluate the impact of grazing on vegetation.

A subsidiary objective was to make a key to the identification of selected food plants through microhistological features.

1.3 Hypothesis

Efforts have been made to ascertain the following hypotheses:

(a) Population of ungulate species are increasing.

(b) All habitat types are equally preferred by all ungulates.

(c) There are seasonal variation in preference of different habitat types.

(d) Changes are taking place in the vegetation community as a result of grazing.

(e) Animals are specialist in regard to their food habits.

(f) Species are competing with each other only for food and not for other resources.

2. STUDY AREA

2.1 History

The present area of Keoladeo National Park was a natural depression which by impounding and controlling water level was developed into a waterfowl refuge by the Maharajas of Bharatpur, some 250 years ago (Ali and Vijayan 1986). The main objective of the rulers was to develop it for game hunting, especially waterfowl. Another objective of the ruler was to provide an alternative grazing ground to the domestic cows whose presence on their crop fields was resented by the farmers. There was also some religious sentiment involved in the concern of the Maharaja for providing a grazing ground for the cows.

2.2 Location

Keoladeo National Park, situated between 27°7.6' to 27°12.2' N and 77°29.5 and 77°33.9' E, is 2 km south-east of Bharatpur city. It is 38 km south-west of Mathura and 50 km west of Agra. The park is located about 180 km south of Delhi ((Fig 2.1).

2.3 Topography

The total area of the park is about 29 sq. km. It is more or less flat with a gentle slope towards the centre forming a depression, the total area of which is about 8.5 sq. km. This is the main submersible area of the Park. The average elevation of the area is about 174 m above sea level.

FIG 2.1

LOCATION OF STUDY SITE, KEOLADEO NATIONAL PARK

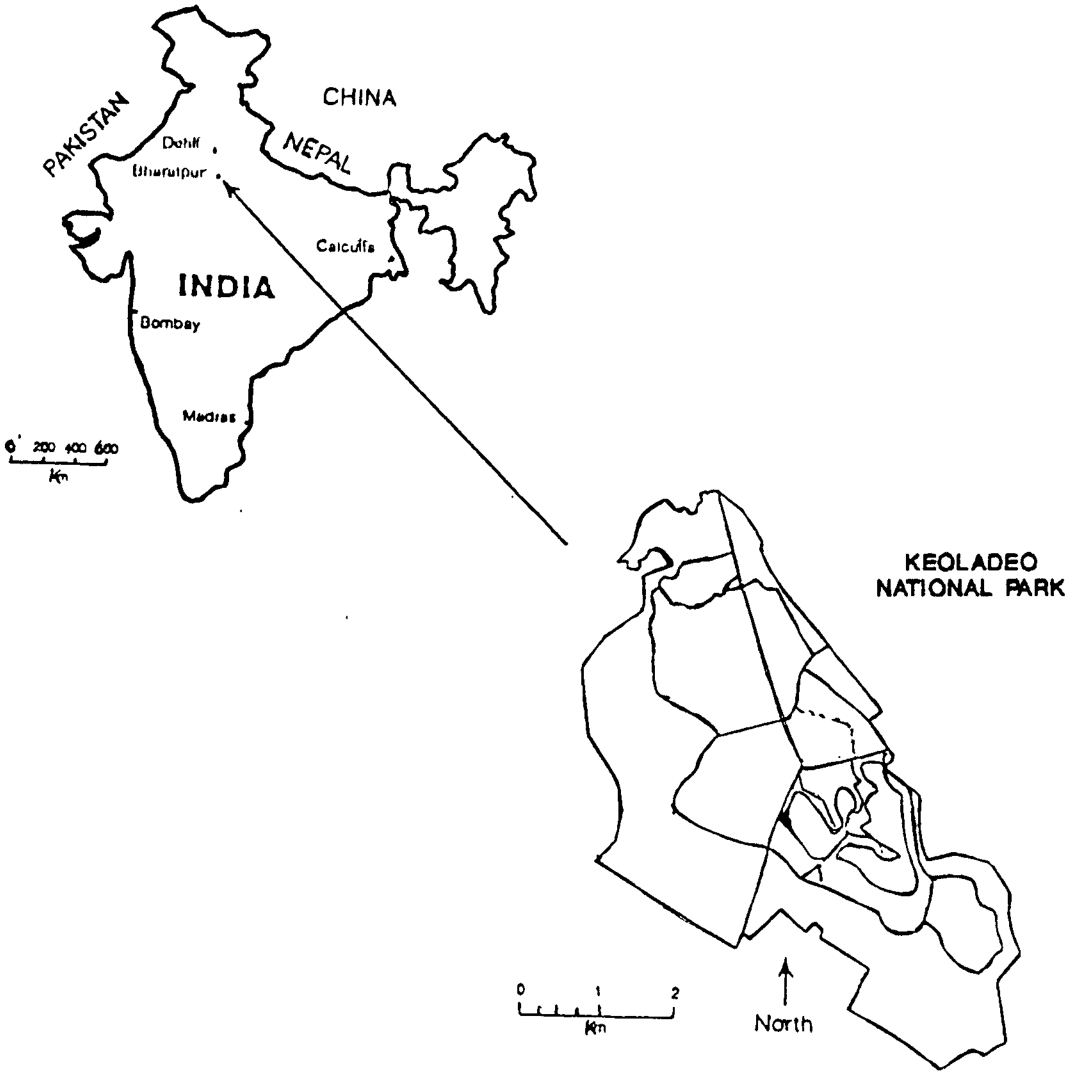
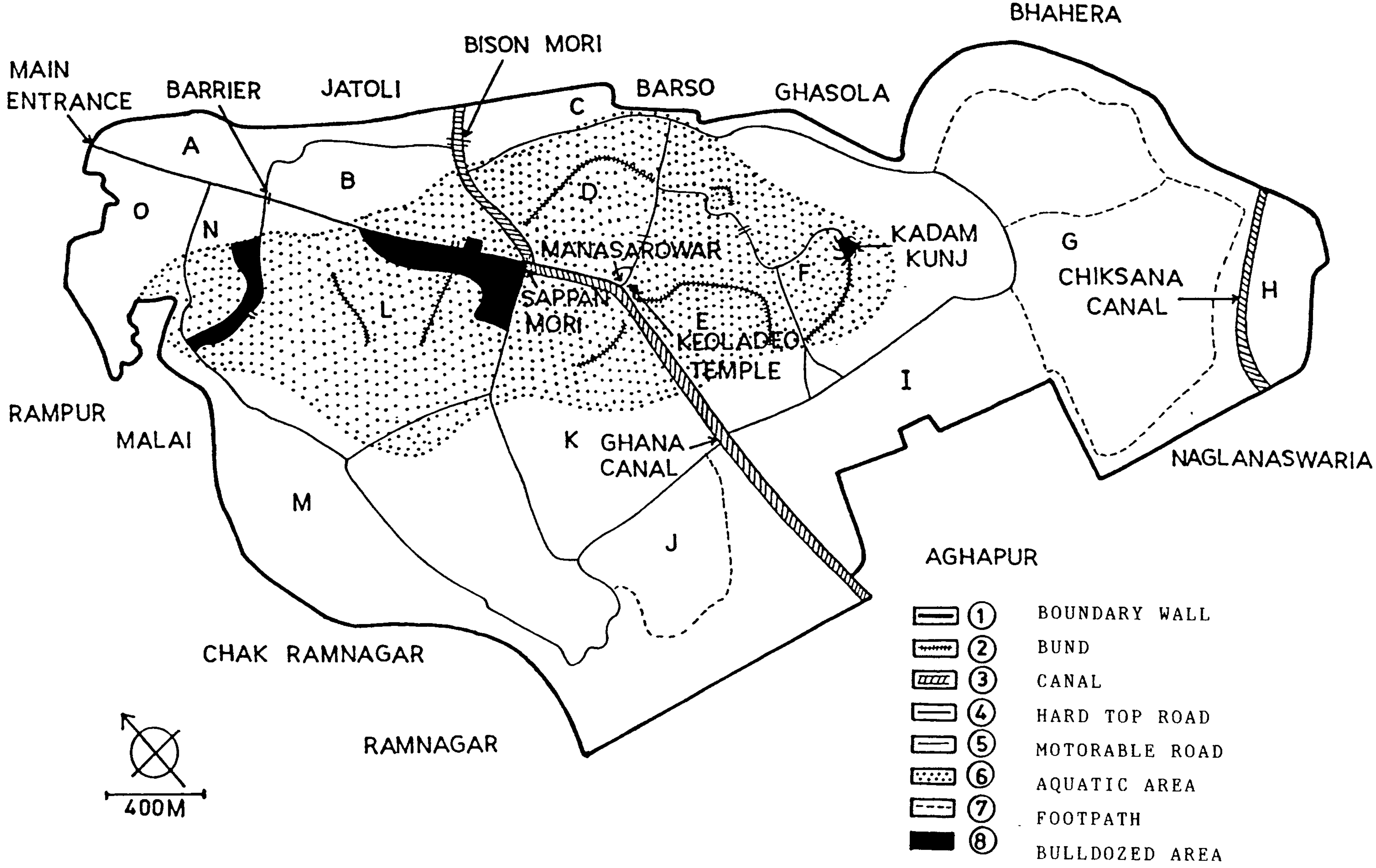


FIG 2.2

MAP OF PARK WITH VILLAGES AROUND



2.4 Boundary

A masonry wall around the border separates the park from the surrounding agricultural fields. There are about 14 villages around the park (Fig 2.2).

2.5 Soil

Thick alluvian dominates the area. Patches of saline soil are common in the terrestrial areas.

2.6 Climate

The climate is sub-tropical with south-west monsoon as the dominant factor. There are three major climatic seasons.

2.6.1 Monsoon

The monsoon during the study year continues from July to October. The mean minimum temperature during monsoon in the study period varied from 22.59°C in the year 1986 to 24.83°C in 1987, whereas mean maximum temperate varied from 34.81°C in 1986 to 37.62°C in 1988. The maximum rainfall during monsoon was 481 mm in the year 1988 and the minimum precipitation was 283.7 mm in the year 1986 (Fig 2.3).

2.6.2 Winter

The winter season continued from November to February. The mean minimum temperature recorded during winter varied from

FIG 2.3

MONTHLY VARIATION IN RAINFALL
DURING JULY 1986 TO JUNE 1989

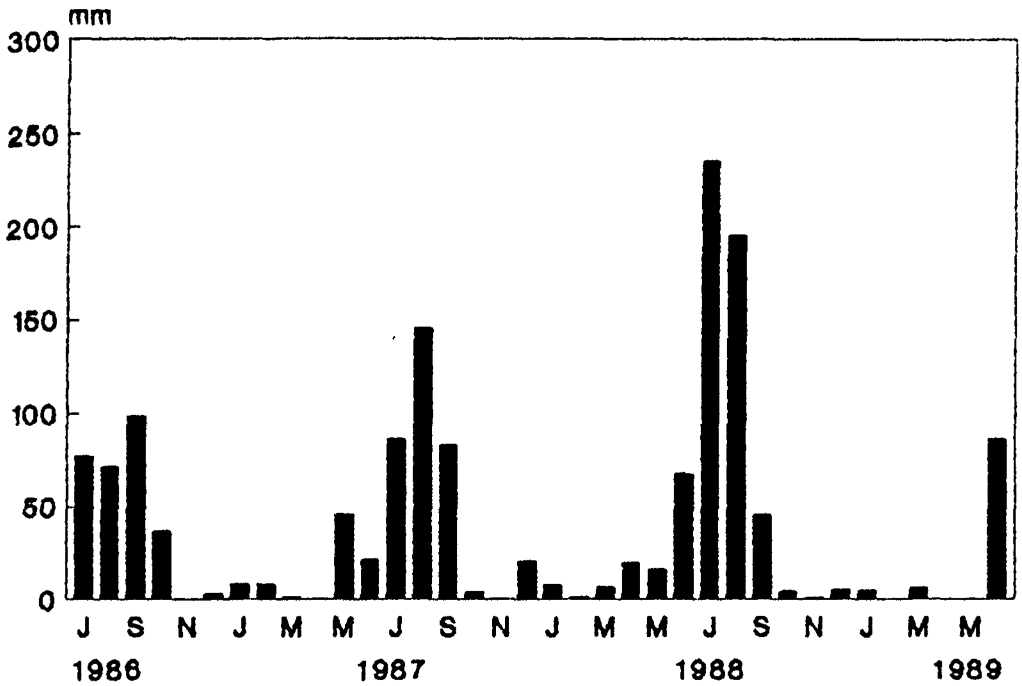
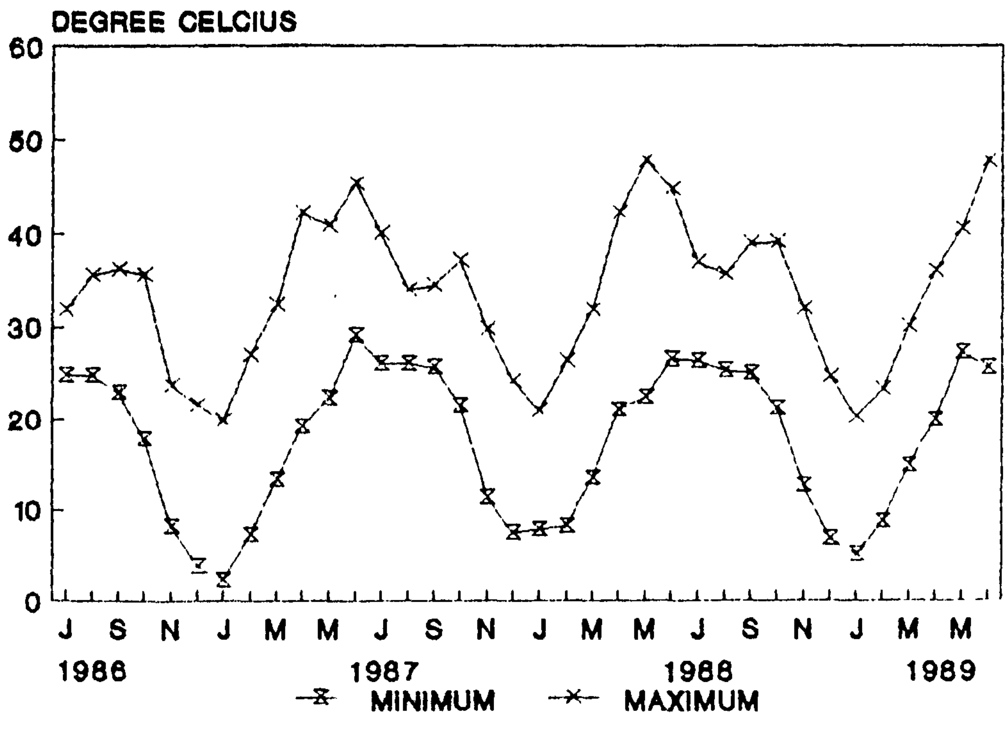


FIG 2.4

MONTHLY VARIATION IN TEMPERATURE
DURING JULY 1986 TO JUNE 1989



5.36°C in the year 1986-87 to 8.68°C in 1987-88. The mean maximum temperature ranged from 20.05°C in the year 1987-88 to 25.05°C in 1988-89. The maximum rainfall during winter was 29.8 mm in 1987 and minimum was 10.4 mm in the year 1988.

2.6.3 Summer

The hot and dry season extended from March to June. The mean minimum temperature during summer varied from 20.83°C in 1987 to 21.86°C in the year 1988, whereas the mean maximum temperature ranged from 38.51°C in 1988 to 41.63°C in 1987 (Fig 2.4). The maximum rainfall was 110.6 mm in the year 1987 and minimum precipitation was 68.00 mm in the year 1986.

2.7 Hydrology

Apart from rain water which is very small in quantity, the major quantum of water is received from Ajan bund, a temporary reservoir outside the Park. The Ajan bund receives water from the two rivers Banganga and Gambir. Water from Ajan bund is released into the park during monsoon (Plate 1).

2.8 Vegetation

The present vegetation type was classified according to Yangambi nomenclature (Perennou and Ramesh 1987) based mainly on physiognomic characters.

The study area comprises of Forest, woodland, scrub woodland, dense to discontinuous thickets, scattered shrubs, savannah woodland to scattered tree savannah, shrub savannah, grass savannah, low grassland, mosaic of several types and wetlands (Fig 2.5). The detailed floral list is given in Appendix VII. The main vegetation types found in the study area are represented as such.

2.8.1 Forest

This habitat is dominated by *Mitragyna parvifolia* which reaches a length of 15-22 m. Only scattered shrubs, represented by *Kirgenelia reticulata* and *Capparis sepiaria* are found in the undergrowth.

2.8.2 Woodland

The tree cover is less dense than in the forest. The habitat consists of only one tree storey which mainly consists of *Mitragyna parvifolia*, *Acacia nilotica* or *Zizyphus mauritiana*. Only scattered shrubs such as *Kirgenelia reticulata* and *Capparis sepiaria* are found in the undergrowth.

2.8.3 Scrub woodland

This vegetation types differs from forest and woodland by the regular presence of thorny shrubs in the undergrowth. In most areas, there is also a second storey of trees under the upper canopy, and sometimes even a third. The common species found in the undergrowth are *Prosopis juliflora*, *Capparis sepiaria*, *Kirgenelia reticulata* and *Salvadora persica*. The two storied scrub woodlands are dominated by non-spiny species such as

Mitragyna parvifolia, Syzyzium cumini. The understory is mainly composed of spiny species such as *Acacia nilotica* and *Zizyphus mauritiana.* The one storied scrub woodland are dominated by armed species such as *Acacia nilotica* and *Zizyphus mauritiana.*

2.8.4 Dense to discontinuous thickets

The dense thickets are regularly interspersed with trees 6 to 12 m high usually *Acacia nilotica* or *Zizyphus mauritiana*, whereas in the discontinuous thickets, a few trees are encountered. In the thicket formation, the soil is either devoid of grass cover or presents a continuous low layer of *Cynodon dactylon* and *Sporobolus* spp.

2.8.5 Scattered shrubs

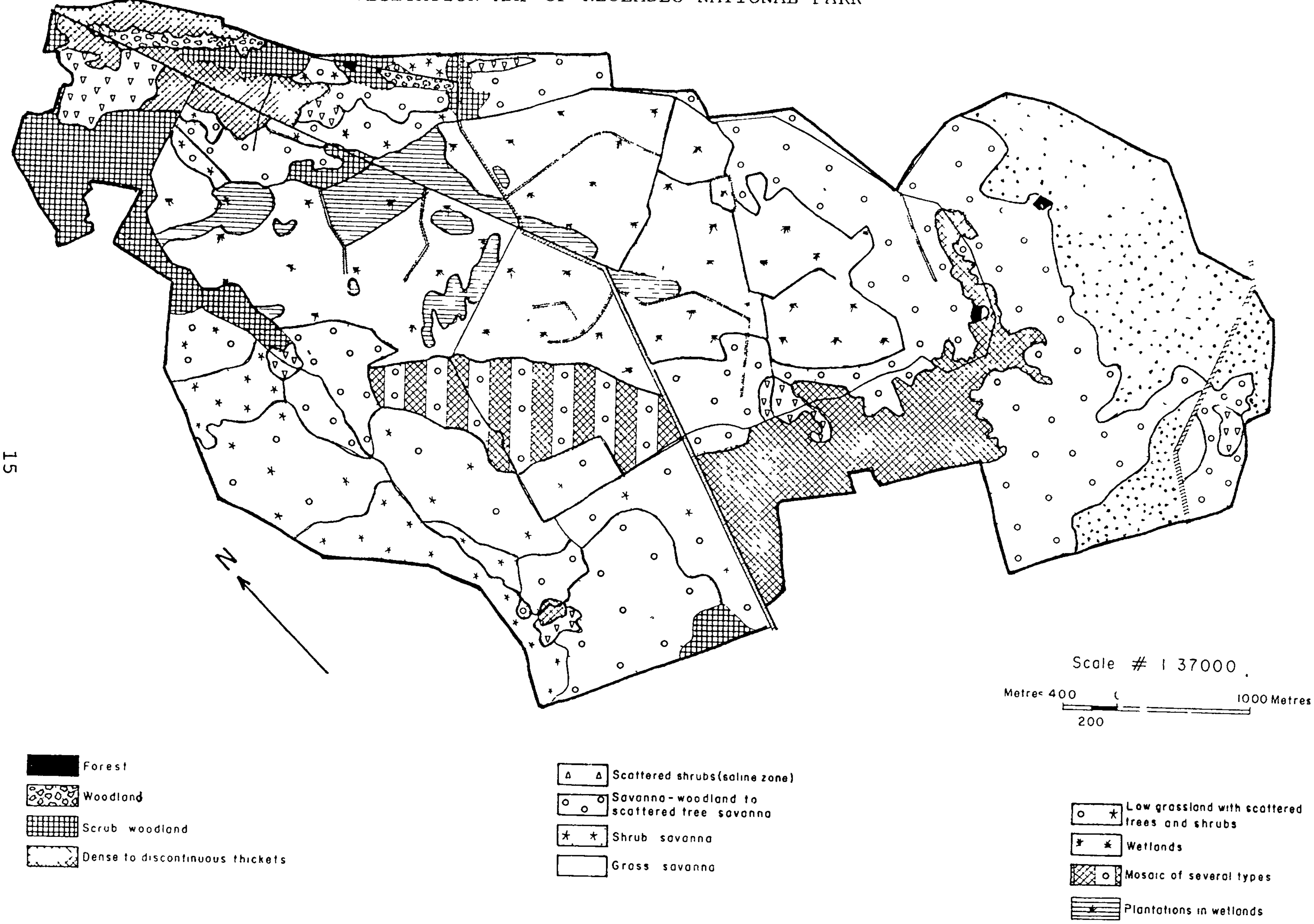
Scattered shrubs are more widely found, especially in saline zones, and consist mostly of *Salvadora persica*, *Salvadora oleoides*, *Prosopis juliflora.* They are regarded here as shrubs and not as trees, since their height rarely exceeds 4-5 m. However, some individuals attain the stature of small trees, 6-8 m in height, with a thick trunk as in the case of *Salvadora* spp.

2.8.6 Savannah woodland to scattered tree savannah

The major tree species found in the habitat are *Mitragyna parvifolia*, *Prosopis cineraria*, *Acacia nilotica*, *Acacia leucophloea*, *Zizyphys mauritiana.*

FIG 2.5

VEGETATION MAP OF KEOLADEO NATIONAL PARK



Generally the tree height varied from 6 to 10 m in all species, but it can reach up to 12-14 m in the case of *Mitragyna parvifolia* and *Acacia nilotica*. The major shrub present in this habitat are *Capparis sepiaria* and *Salvadora persica*. The major grass species found in this habitat are *Vetiveria zizanioides*, *Desmostachya bipinnata*, *Cynodon dactylon* and *Dicanthium annulatum*.

2.8.7 Shrub savannah

The habitat is dominated by shrub less than 5 m tall. The dominant species are *Salvadora persica*, *Capparis sepiaria*, *Balanites roxburghii*, *Prosopis juliflora*, *Dichrostachys cinerea*. The main grass is *Desmostachya bipinnata*, *Sporobolus helvolus* and *Iselema laxum*.

2.8.8 Grass savannah

This habitat is covered with a continuous 2 m high, *Vetiveria zizanioides* layer with *Desmostachya bipinnata* forming a lower stratum. The woody vegetation is almost or totally absent, with trees usually standing more than 50 m apart.

2.8.9 Low grassland

This habitat has a continuous layers of low grasses such as *Cynodon dactylon*, *Sporobolus* spp. *Dicanthium annulatum*, *Eragrostis* spp., which are 5-10 cm in height. A few trees and shrubs are scattered or sometimes very scattered. Among the trees *Acacia nilotica* are dominated whereas, among the shrub, *Salvadora persica* and *Prosopis juliflora* are dominant.

2.8.10 Mosaic of several types

Mosaic of several types consists of mixture of several habitat such as scrub woodland, dense to discontinuous thickets, scattered shrubs, savannah woodland to scattered tree savannah and grass savannah.

2.8.11 Wetlands

The aquatic vegetation consists mainly of emergent, rooted floating, submerged and free floating types of plants (Ali and Vijayan 1983). The major emergent plants important to herbivores are *Paspalum distichum*, *Cyperus alopecuroides*, *Cyperus rotundus*, *Scirpus tuberosus*, *Scirpus articulatus*, *Eleocharis plantoginea* and *Ipomoea aquatica*. Rooted floating includes *Nyphoides cristatum* and *Nymphoides indica*. The major submerged plants are *Hydrilla verticillata*, *Utricularia inflexa*, *Potamogeton crispus*, *Ceratophyllum demersum* and *Vallisneria spirolis*, *Lemna paucicostata*, *Azolla pinnata* and *Wolffia arrhiza* are the main free floating types. Apart from these, numerous raised mounds are present in the aquatic area and *Acacia nilotica* is planted to attract colonial nesting birds.

The poor rainfall and inadequate water supply (1986-87) from the Ajan bund led to a drought condition inside the Park and hence, most of the aquatic area during summer became dry and appeared as an open grassland (Plate 2). In addition to that, a part of the area was bulldozed by the forest department to remove the excessive growth of grass and this created an open patch.

2.8 Fauna

The vertebrate fauna of Keoladeo National Park is quite rich. According to Vijayan (1987) 40 species of fish, 5 species of amphibia, 28 species of reptiles and over 317 species of birds have been described. Twenty nine mammalian species have been recorded (Appendix VIII) and the six species, on which the present study was conducted, are described in the next chapter (Study Species).

3. STUDY SPECIES

3.1 Chital (*Axis axis*)

Chital belongs to the genus *Axis* and is the third largest deer inhabiting the plains of India. The average weight of an adult male is 70 kg while the females are about 20 kg lighter. The average height of a male is 90 cm at shoulder level and that of a female is 75 cm. Its coat is rufous brown and covered with white spots. There is a dark dorsal stripe, running down from the nape to the tip of the tail. The underparts, inside of the legs, undertail, and inner side of the ear are white. The antlers are brownish with paler streaks and ivory coloured tips.

The North Eastern part of Gujarat State forms the western limit to its distribution, from where it extends eastwards through most northern provinces of India except the Punjab. Assam forms its eastern limit. They also occupy forested areas of Peninsular India and Sri Lanka.

Chital is gregarious with little nocturnal activity. They are seen in herds of usually ten to thirty which may contain two to three stags. Assemblages numbering upto several hundred have been occasionally seen. It is worth mentioning that the species is distributed in disjointed patches along its range because of large scale habitat destruction and deforestation. It is mostly confined to the national parks and sanctuaries where hunting is banned and the habitat is comparatively in a better shape. Some spill over populations are found around the national parks and sanctuaries.

3.2 Sambar (*Cervus unicolar*)

The Sambar is the largest and most widely distributed seen in India. It belongs to genus *Cervus*. Adult stags measure 122 to 150 cm at the shoulder and weigh from 225 to 320 Kg. Female are smaller and weigh about 164 Kg. The winter coat of the Sambar is grey-brown to dark brown. Adult stags are slightly darker in colour than hinds. The summer coat is brown to chestnut brown. The rump, the underside of the tail and the inner side of the legs are light to rusty brown. Antlers are stout, rugged and normally three tined.

The Sambar is distributed throughout the oriental region wherever there is undulating ground of hilly country with forests. It is found from Sri Lanka and the South and throughout the Peninsula to the fringe of the Himalayas in the north.

Its habits are nocturnal. Being very alert and shy of man it is difficult to locate, much less to observe for prolonged periods (Schaller 1967, Prater 1965). But the case at Keoladeo National Park is entirely different where Sambars are frequently seen grazing during day hours in aquatic area especially in the winter and rainy season. Their sense of sight is moderate. They have a keen sense of smell and hearing. Both stags and hinds are often found singly, but small herds from four or five to a dozen in number are commonly met. The males fight for territory (Prater 1965). Sambars are forest loving animals (Prater 1965, Brander 1923).

3.3 Blackbuck (*Antilope cervicapra*)

The Blackbuck till about five decades back, was the commonest and most conspicuous antelope in India (Brander 1923). The Blackbuck is the sole representative of the genus antelope of the subfamily Antelopinae. Males are 74 to 84 cm at shoulder and weigh about 35 Kg. Females are slightly smaller and weigh about 32 Kg. Adult bucks are blackish brown above turning to almost black in very old animals and white below. Colour of does and subadult bucks is yellowish-fawn above and white below. The horns are ringed and spiral three to six time.

Blackbuck is distributed from Pakistan along the foot of the Himalayas to Bangladesh and throughout Peninsular India. It is not found in Assam, West Bengal, Kerala and Sri Lanka.

Blackbuck are generally diurnal and found in herds of 10 to 20. Their sense of hearing is moderate, and they have a fair sense of smell, and keen eye sight. In the contrast to the harem formation reported by several workers in different areas, no harem formation has so far been observed in Keoladeo National Park, the reason are not clearly understood. However, the female group make a large, daily circuit and territorial males join the females as they pass through their territories. Blackbuck has the habit of occasionally springing into the air. It comes to the same spot to deposit dropping.

3.4 Nilgai (*Boselaphus tragocamelus*)

The Nilgai is a member of the Tribe Boselaphini. A male stands 130 to 142 cm at shoulder and weighs about 200 Kg. Females are smaller weighing 109 to 132 Kg. Adult bulls are iron grey and blue grey. Subadult males and all females are light brown in colour. Both sexes have dark and white markings on their heads, ears, underparts, fetlocks and tail. Both sexes have a short bristly mane.

The distribution of the Nilgai is from the Himalayan foothills, southward through central India to northern parts of Karnataka. It is not found in Eastern Bengal, Assam, Malabar coast or Sri Lanka (Brander 1923, Prater 1965).

Males and females remain segregated except during the breeding season, when breeding herds are formed. Four to ten are usually seen together, sometimes as many as thirty or even more. Adult solitary bulls are territorial. Senses of smell and sight are good while hearing is moderately developed in Nilgai. It has a habit of defecating in the same location like other antelopes (Schaller 1967, Brander 1923, Prater 1965). Schaller (1967) suggested that they might be territorial markers, but Ables (1983) feels that defecation has social importance though its function is unknown.

3.5 Wild boar (*Sus scrofa*)

The Wild boar belongs to the family Suidae. Males are considerably larger than females and stand 84 to 91.5 cm at the shoulder. According to Prater (1965) the weight of the male may exceed 230 Kg which is almost equal to that of the European Boar (Robert 1977). An adult is a large bulky animal with head appearing as directly joined to the trunk, a barrel shaped body with disproportionately thinner legs. The head has a long muzzle terminating into a disk like structure especially adapted for foraging. The colour of the animal is black mixed with grey, rusty brown and white. The young are brown and have longitudinal stripes. The tushes curve outwards and project from the mouth. These are well developed in the males.

The Indian Wild boar is widely distributed in most parts of the Indian Sub-continent, including the lower reaches of the Himalayas, Burma and Sri Lanka.

Wild boar is normally a social animal resting and feeding in small groups. Adult males are usually solitary. They are largely nocturnal feeders. The sense of smell is acute, the eyesight and hearing moderate.

3.6 Feral cattle (*Bos indicus*)

Jerdon (1874) has divided the sub family Bovinae into three groups one of which Taurine has been subdivided by Blyth into (a) Zebus (b) Taurus and (c) Gavaeus. The common humped cattle of

India, seem closest to the feral cattle, belong to the division Zebus.

Jerdon states in "Mammals of India" that in many parts of the country small herds of these animal have run wild. Cows of this type, disowned by their former owners, several generations back, have also found their way into Keoladeo National Park. Being free from domestication their behaviour and appearance has changed to some extent. These are healthier and are comparatively shy of human beings. In all other respects they are like domestic cattle.

4. POPULATION

4.1 Introduction

The population is an ultimate self-reproducing grouping of conspecific individuals, which occupies a definite area over an evolutionary long span of time to form an independent genetic system and an ecological niche of its own (Yablkov 1986).

The interest of an ecologist in the study of wild or natural populations of animals is something comparatively new, for at the beginning of this century very little attention was paid to the structure and dynamics of natural populations, and the difficulties that impeded the study of them seemed insurmountable.

Elton (1927) in his pioneering work, drew attention to the importance of studying numbers and the fluctuation in numbers of animal population and commented on the necessity of knowledge on a subject which is a prequisite in the applied ecology of wildlife management.

Since last three decades a number of workers came out with different methods of estimating population and biomass of ungulates (Rodgers *et al.* 1958; Neff 1968; Dzieciolowski 1976; Eberhardt 1978; Chua and Tan 1980; Tak and Lamba 1980).

Most of the studies on ungulate populations were carried out by different workers in African habitats (Lamprey 1964; Coe *et al.* 1976; Barnes and Douglas 1982; Rowe-Rowe and Scotcher 1986) and only few studies have been done in South Asian countries (Eisenberg *et al.* 1970; Eisenberg and Seidensticker 1976; Seidensticker 1976).

In our country most of the studies have been done on a single species populations (Rice 1984; Green 1985; Prasad and Rao 1984). Very few studies have been done on the population of all the ungulates of a geographical or an ecological unit which includes the work of Prasad *et al.* (1978) and Berwick (1974).

Proper management requires a good understanding of all aspects of the concerned wildlife populations; size, dynamics, trends and their underlying causes. Population manipulation, which sometimes becomes necessary can also be safely resorted to only with full knowledge of the above mentioned and several other things, enabling the manager to foresee likely developments in the future, their causes and probable consequences. The present study was an attempt to provide the requisite knowledge in regard to the ungulate population (all species) in Keoladeo National Park.

4.2 Methodology

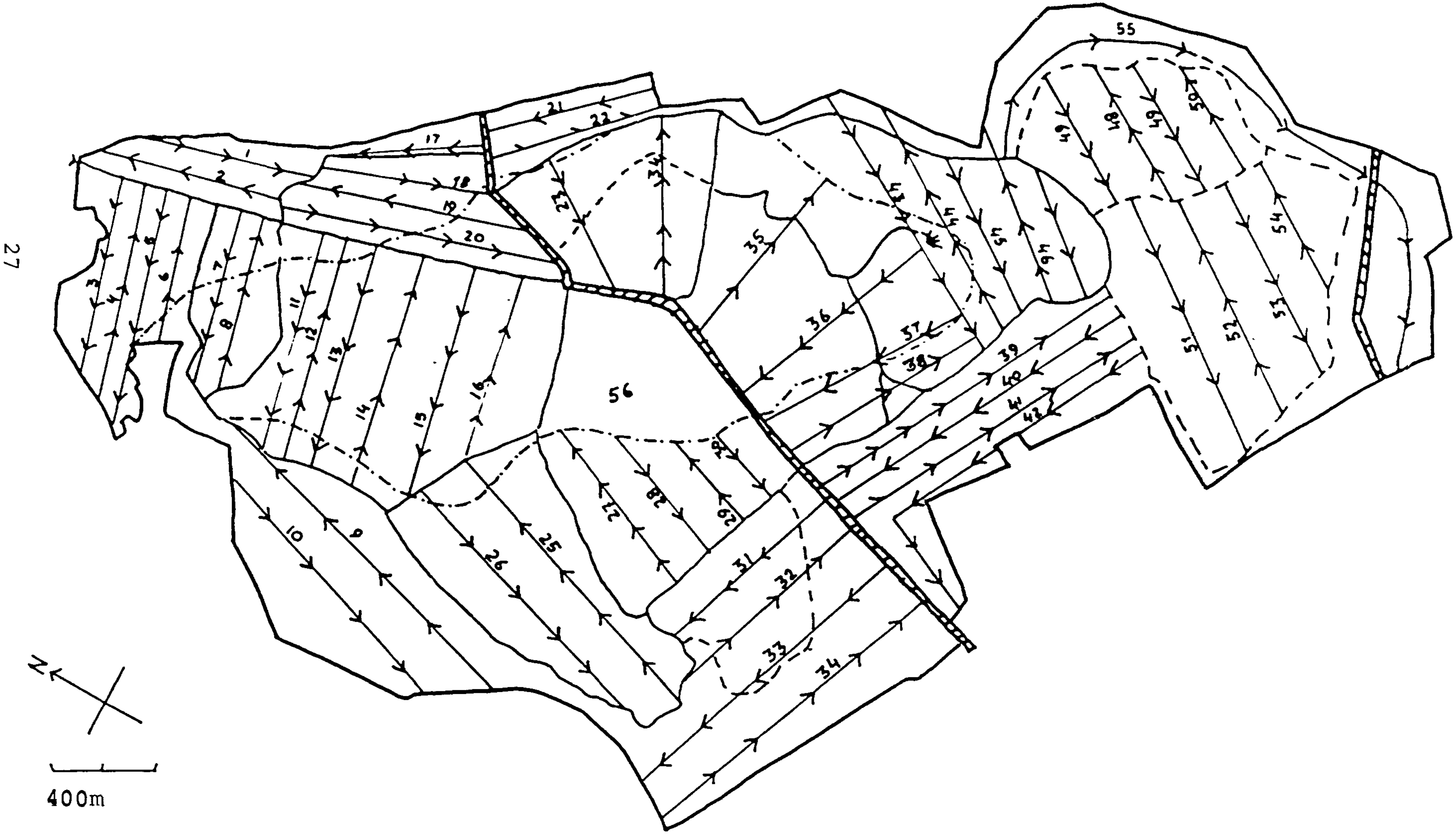
For maximum possible accuracy in census, following three methods were applied alternately.

4.2.1 Simultaneous count

Simultaneous census was carried out along 60 transects, during April-May (1987,1988,1989) when visibility is best. Data collected on two consequitive evenings were pooled and the

FIG 4.1

Transects followed for simultaneous count of mammals



average was calculated. A total of 60 enumerators divided into 30 groups of two person each took part in the census operation and each group was assigned two transects (varying in length from 1.5 to 2 Kms) 100-200 meters apart. The transects were carefully located to encompass all habitat variations and to evenly cover the entire Park (Fig 4.1).

Following information was collected by each participant.

(a) Species wise number of individual animals seen.
(b) Sex and approximate age of each observed animals.
(c) Location of the observed animal (direction in relation to the observer)
(d) Time at which the animal was observed.

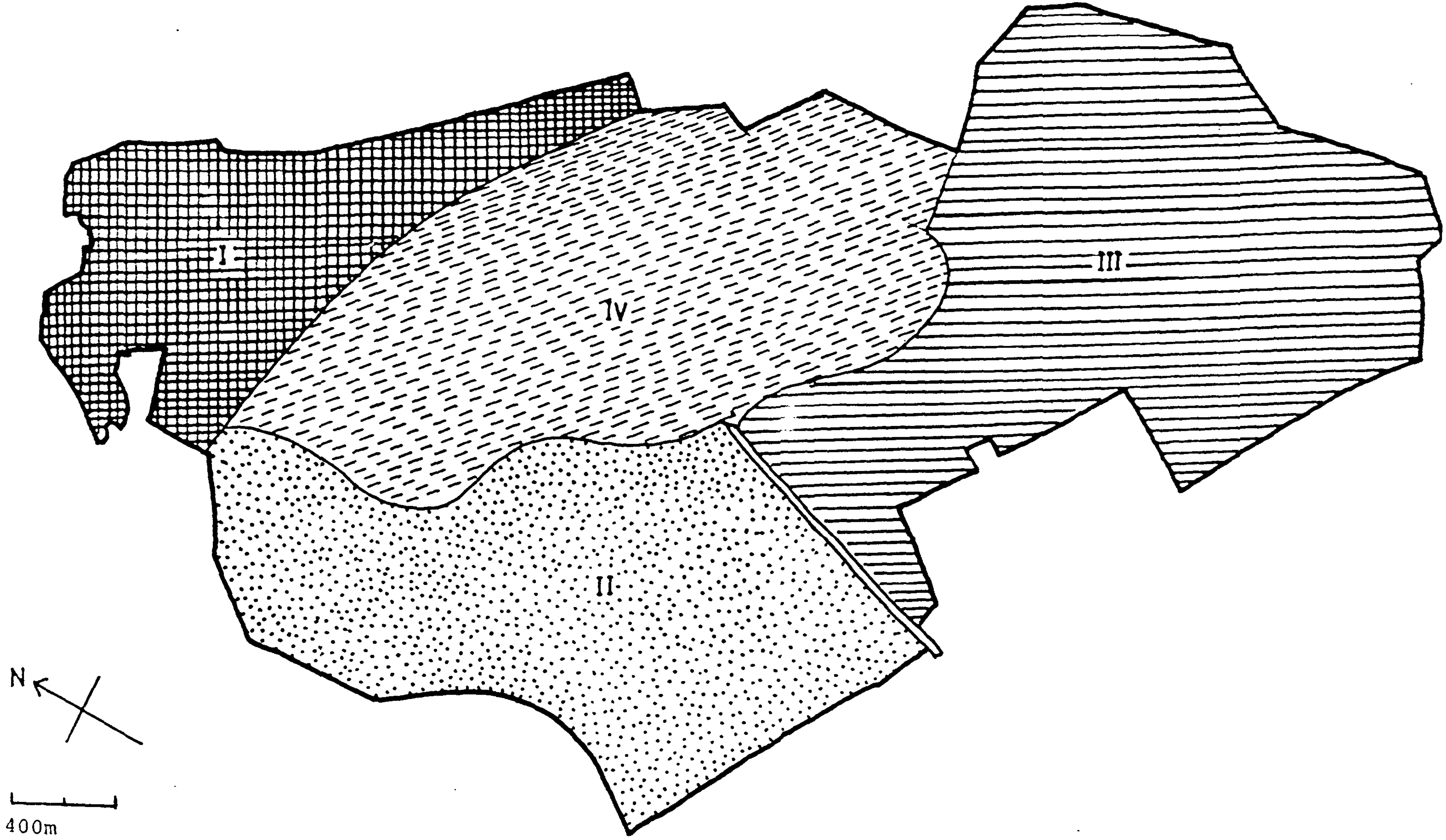
Though this method (census along transect) is generally regarded as basic, it was found sufficiently accurate under the prevailing conditions. Feral cattle and Chital for example were seen only in large herds in specific areas and almost all of them could be counted on the same day, presumably without duplication. Double counting and inaccuracies were further minimised by cross checking with concerned fellow-enumerators, of the sighting time and direction/location and by making consequent alterations in the figures.

4.2.2 Zonal count

To bring about greater accuracy in census, the Park was divided into four zones (Fig 4.2) and counting was done in all the four zones. Counting was done by criss-crossing the entire area from 6 hours to 10 hours and from 14 hours to 18 hours.

FIG 4.2

MAP SHOWING THE FOUR DIFFERENT ZONES



Each zone was covered eight times; four times in the morning and four times in the evenings. Only one count could be done in a day and the zones were covered in rotation. The data of all the eight counts in each zone was pooled and the average number of animals was calculated. Due care was taken to avoid double count as far as possible. Zonal count was conducted only in 1988 and 1989.

4.2.3 Intensive count

Intensive count was found to be feasible for only Sambar and Blackbuck as the population of these species in the Park is quite small. The first step was to identify the herds of both these species and then the number of animals in each herd was counted. The herds were constantly and regularly watched throughout the study period.

4.2.4 Sex and age classification

Sex and age classification of all the species of ungulates was done using the criteria described by Spillet (1966) and Schaller (1967). Both sex identification and age estimation were done on the basis of body size, colour,antlers and horns.

These criteria could not be employed in the case of Wild boar which preferred mainly thick vegetation and, seldom allowed a clear view of the whole body and hence the age and sex of very few animals could be recorded.

Whenever the sex and age of the animals (any species) could not be determined a separate entry was made under the head "indeterminate".

4.2.5 Exponential rate of increase

The population growth was measured by exponential rate of increase following the formula of Caughley (1977), Begon and Mortimer (1981).

$$Nt = Noe^{rt}.$$

The constant `e' is the base of natural logarithum

Nt = Initial population

No = Final population

t = time.

4.3 Result

4.3.1 Population size

The results of census of four species viz: Chital, Nilgai Feral cattle and Wild boar carried out by simultaneous count and zonal count are given in table 4.1 and 4.2 respectively.

The census data of Sambar and Blackbuck collected through intensive count is given separately in table 4.3

The average number of animals (calculated from the zonal count) and their standard deviation was worked out for different zone, which is given in table 4.5 and 4.6

The sex ratio of all the ungulates species is given table 4.7.

Table 4.1

Population structure of ungulates at Keoladeo National Park
(Simultaneous count)

	Male			Female			Young			Total		
Year	87	88	89	87	88	89	87	88	89	87	88	89
Chital	76	88	79	162	169	180	41	26	31	279	283	290
Nilgai	55	86	86	114	98	107	22	18	23	191	202	216
Feral cattle	286	322	279	732	798	737	143	174	160	1200#	1294	1176
Wild boar	27	5	5	16	2	6	12	1	8	65*	8	26**

* Including 10 unsexed
** Including 7 unsexed
\# Including 39 unsexed

Table 4.2

Population structure of ungulates at Keoladeo National Park
(Zonal count)

	Male		Female		Young		Total	
Year	88	89	88	89	88	89	88	89
Chital	77	71	158	170	22	28	257	269
Nilgai	78	82	90	96	15	18	183	196
Feral cattle	214	209	542	545	136	131	892	885
Wild boar	3	21	5	33	2	18	12*	84**

* Including 2 unsexed ** Including 12 unsexed

CHITAL

The census figures for this species arrived at through zonal and simultaneous count methods did not differ much; 9.1% difference in the estimates through zonal and simultaneous counts (1988 figures) and 7.24% difference in estimates through the two methods (1989 figures). Zonal count was done only during 1988 and 1989 and the data indicates an increase from 257 to 269. Simultaneous count was done for three consequitive years i.e. 1987, 1988 and 1989 and the data indicates an increase from 279 to 290.

The male to female average ratio comes to 1:2.1 while ~~it~~ the average ratio of female to young comes to 5.41:1.

SAMBAR

The results of intensive counts indicate that Sambar population increased slightly from 21 in 1987 to 22 in 1989. Sambar were mostly seen in two herds of 10 to 11 in each. The average ratio of male to female was 1:1.34 and female to fawn was 4.72:1.

BLACKBUCK

This species was censused only by intensive count method as mentioned earlier. The data shows an increasing trend in numbers; from 18 in 1987 to 20 in 1988 and 23 in 1989. Blackbuck was also seen in two groups of 9-11 each and the average ratio of male to female was 1:1.69 and female to young was 4.2:1.

Table 4.3

Population structure of the Sambar and the Blackbuck during 1987,1988 & 1989 (Intensive count)

	Male			Female			Young			Total		
Year	87	88	89	87	88	89	87	88	89	87	88	89
Sambar	7	8	9	11	10	11	3	2	2	21	20	22
Blackbuck	5	7	8	10	11	12	3	2	3	18	20	23

Table 4.4

Exponential rate of increase (r) of population of ungulates at Keoladeo National Park

	1987-88	1988-89	1987-89	1966-89
Chital	0.014	0.024	0.0193	-0.0014
Sambar	-0.048	0.095	0.023	0.0039
Blackbuck	0.105	0.139	0.1225	-0.039
Nilgai	0.055	0.067	0.0615	0.015
Feral cattle	0.075	-0.095	-0.0101	--
Wild boar	-2.094	1.17	-0.458	-0.046

NILGAI

Census of this species was carried out by two methods viz: Zonal count and simultaneous count. The data indicates an increasing trend in the estimated number from 191 in 1987 to 216 in 1989 (simultaneous count) and 183 in 1987 to 196 in 1989 (zonal count). The estimates through the two methods also do not differ much; 9.4% in 1988 and 9.25% in 1989.

The average ratio (calculated from the data of three years) of male to female for the Nilgai was 1:1.48 whereas, the average ratio of female to young was 5.09:1.

FERAL CATTLE

The main problem faced in censusing Feral cattle was that it was difficult to distinguish between Feral and domestic cattle (sneaking into the park through the broken parts of the boundary wall). These two types get mixed up and can be differentiated only on the basis of their behaviour - tolerance of human beings at closer quarter, which require closer and longer observation. It was, therefore, possible only during zonal count as only I took part in this method. Consequently the figures arrived at through simultaneous count method appear higher because these include the domestic cattle too. It was estimated that 300-400 domestic cattle were present in the park during the study period. The zonal count estimates pertain mostly to Feral cattle and hence are lower than the simultaneous count estimates. If, however, the estimated average (i.e. 350) number of domestic cattle is excluded from the estimates of two methods narrows down to 65 for 1989 and to 52 in 1988.

Table 4.5

Population of ungulates at Keoladeo National Park during 1988 in different zones (Zonal count)

	First zone	Second zone	Third zone	Fourth zone	Total
Chital	173 ± 22.32	17 ± 7.56	5 ± 5.33	62 ± 13.4	257
Nilgai	20 ± 1.41	65 ± 2.54	47 ± 2.71	51 ± 5.6	183
Feral cattle	-	126 ± 22.25	219 ± 13.22	547 ± 27.85	892
Wild boar	7 ± 3.2	3 ± 2.77	2 ± 1.06	-	12

Table 4.6

Population of ungulates at Keoladeo National Park during 1989 in different zones (Zonal count)

	First zone	Second zone	Third zone	Fourth zone	Total
Chital	171 ± 9.03	20 ± 2.41	12 ± 6.1	66 ± 4.03	269
Nilgai	23 ± 1.72	74 ± 2.44	47 ± 2.61	52 ± 3.62	196
Feral cattle	-	136 ± 7.17	226 ± 98	523 ± 13.66	885
Wild boar	49 ± 6.04	23 ± 10.23	12 ± 2.13	-	84

Table 4.7

Summary of sex ratio and percentage of ungulates of Keoladeo National Park

		Male:Female	Female:Young	% Male	% Female	% Young
	1987	1:2.13	3.95:1	27.2	58.06	14.69
Chital	1988	1:1.92	6.5 :1	31.09	59.71	9.18
	1989	1:2.27	5.8 :1	27.24	62.06	10.68
	1987	1:1.57	3.66:1	33.33	52.38	14.2
Sambar	1988	1:1.25	5:1	40.0	50.0	10.0
	1989	1:1.22	5.5:1	40.9	50.0	9.09
	1987	1:2	3.3:1	27.77	55.55	16.66
Blackbuck	1988	1:1.57	5.5:1	35.00	55.00	10.00
	1989	1:1.5	4:1	34.78	52.77	13.04
	1987	1:2.07	5.18:1	28.79	59.68	11.55
Nilgai	1988	1:1.13	5.44:1	42.57	48.51	8.91
	1989	1:1.24	4.65:1	39.81	49.53	10.64
	1987	1:2.55	5.11:1	23.83	61.0	11.91
Feral cattle	1988	1:2.47	4.58:1	24.88	61.66	13.44
	1989	1:2.64	4.6:1	23.72	62.67	13.60

The average ratio of male to female for the Feral cattle was 1:2.53 while the average ratio of female to young was 4.76:1.

WILD BOAR

A peculiar problem was encountered while attempting to census Wild boar. The animal is extremely shy of human beings and lives in more or less dense habitat - in the midst of bushes. It is almost impossible to see all the animals in any area at a time. However, the two methods viz: zonal and simultaneous count were applied without much success. A glance at the data given in table 1.1 and 1.2 clearly indicates very wide difference and hence these estimates should not be relied upon. But unfortunately no other reliable method feasible for Wild boar has so far been evolved anywhere.

Further doubts on the accuracy of the data arose when upto 30 animals were observed by chance at one location alone. It can, therefore, be assumed that a much higher number of animals live in the park than the estimated number. Age and sex data could not be collected for reasons already stated above.

4.3.2 Density and biomass

Considering that there was not much fluctuation in the ungulate population (all species taken together) during the study period, the density was calculated from the average number of three simultaneous counts except in the case of Wild boar for which only 1987 data was taken into consideration.

Table 4.8

Density and biomass of wild ungulates in Keoladeo National Park

Species	Numbers[1] Adult	Young	Density	Average Wt. in Kg[2] Adult	Young	Biomass Kg/Km^2
Chital	251	33	9.79	50	25	461.20
Sambar	20	2	0.75	180	65	128.62
Blackbuck	20	3	0.79	40	10	28.62
Nilgai	182	21	7.0	225	55	1451.8
Wild boar	53*	12	2.24	150	15	280.34
Sub total Wild ungulates						2350.58
Feral cattle	1051	160	41.75	295	90	11187.75
Total						13538.33

1 - Average number from 3 simultaneous count

2 - From Berwick (1974)

* - Included only 1987 data

The maximum density was of Feral cattle $41.75/Km^2$ (Table 4.8) and the minimum was of Sambar $0.75/Km^2$. The total biomass was calculated to be 1.3×10^4 kg/Km^2 of which the Feral cattle alone constitute 1.1×10^4 Kg/Km (85%).

4.3.3 Exponential rate of increase (r)

The exponential rate of increase was calculated considering all the ungulate species together during the study period and was compared with the previous data collected by Spillet *et al.* (1966). The values are summarized in table 4.4.

The `r' value of Chital during 1987-89 was 0.0193 but it was -0.0014 during 1966-1989. The same pattern was observed in Blackbuck; where the `r' value for 1987-89 was 0.122 while in 1966-89 it was (-0.039). The negative pattern shows declining of trend from 1966 to 1989.

The `r' value for Sambar and Nilgai during 1987-89 was 0.023 and 0.0615 respectively while during 1966-89 it was 0.0039 and 0.015 respectively. Though the `r' value for both the species during 1966-89 was low it indicate an increasing trend.

The `r' values of Wild boar during 1987-89 and 1966-89 were -0.458 and -0.046 respectively showing a negative trend.

The data on Feral cattle for the year 1966 was not available and hence, `r' value could be calculated on the basis of data for the study period only.

Table 4.9

Mortality of the ungulates during (a) 1987
(b) 1988 and (c) 1989

(A)

	Male	Female	Young	Unsexed	Total
Chital	15	4	2	-	21
Sambar	1	-	-	-	1
Blackbuck	1	-	-	-	1
Nilgai	2	1	-	-	3
Feral cattle	3	9	4	3	19
Wild boar	4	3	1	-	8

(B)

	Male	Female	Young	Unsexed	Total
Chital	14	2	-	-	16
Sambar	-	1	-	-	1
Nilgai	5	2	-	-	7
Feral cattle	14	30	7	11	62

(C)

	Male	Female	Young	Unsexed	Total
Chital	3	1	-	-	4
Feral cattle	4	7	2	2	15
Nilgai	1	1	-	-	2
Wild boar	2	-	-	-	2

4.3.4 Mortality

Altogether 41 Chital, 2 Sambar, 1 Blackbuck, 12 Nilgai, 10 Wildboar and 96 Feral cattle died during the study period. The detail of their sex and age structure are presented in table 4.9.

The maximum mortality of Chital was in the years 1987 and 1988 while that of Nilgai and Feral cattle was in 1988. Mortality of Wild boar was maximum during 1987. Mortality of Sambar was one each in 1987 and 1988. The only Blackbuck that died during the study period was in 1987.

There was higher mortality of male Chitals than of females. Out of 41 cases 32 were males, 7 were females and two could not be sexed as only the bare carcass was found.

The mortality of Feral cattle during 1988 was 62 which was the highest during the study period. Mortality was highest during summer. Thirteen carcasses located were intact and fresh, and indicated that the animals were emaciated. Around 15 were seen near the edge of water. These animals had presumably gone to take water and got bogged down in soft soil and could not free themselves as they were very weak (Plate 4). Two of the females that died were pregnant.

4.3.5 Predators

Out of the 41 cases of mortality of chitals 32 were presumably killed by the stray dogs. Usually the dogs chase the victim towards aquatic area and as soon as the animal gets into the water the dog pounce on the scrotal sac and immobilize it before killing (Plate 3).

The other species which were the victim of stray dogs were Nilgai, Sambar, Wildboar and Feral cattle. Blackbuck was not seen killed by these dogs.

4.4 Discussion

Population size

The simultaneous count and zonal count methods proved to be equally suitable techniques for estimating the population of ungulates in the Keoladeo National Park. The only disadvantages of simultaneous count method was that it needs a large number of trained personnel to accomplish the objective in the field. apart from that this method is not very appropriate for those species whose population is small.

When both the methods (simultaneous and zonal count) were compared it was seen that all the ungulate species showed less figure in zonal count. It may be due to the average number taken from eight counts while the simultaneous count showed a higher figure because the average were taken from two counts.

The temporal distribution of all the ungulates in Keoladeo National Park is governed to a great extent on the uneven distribution and availability of forage and water on different zones. The differences in number of animals in different zone might be due to the differences in the availability of resources

Table 4.10

Comparative sex and age ratio of some wild ungulates from studies by Schaller (1967)

		Male : Female	Female : Young
	West Kheri	1 : 1.27	3.81 : 1
	Vanibihar	1 : 1.37	1.88 : 1
Chital	West Bastar	1 : 1.44	1.88 : 1
	Kanha	1 : 1.39	1.49 : 1
	Gir	1 : 2.5	3.3 : 1
	Keoladeo National Park	1 : 2.1	5.41 : 1
	Gir	1 : 1.53	2.32 : 1
Sambar	Kanha	1 : 3.36	2.96 : 1
	Kaziranga	1 : 1.85	3.05 : 1
	Keoladeo National Park	1 : 1.34	4.72 : 1
Blackbuck	Kanha	1 : 2.2	2.7 : 1
	Keoladeo National Park	1 : 1.69	4.2 : 1
Nilgai	Vanibihar	1 : 2.7	0.93 : 1
	Gir	1 : 2.5	2.00 : 1
	Keoladeo National Park	1 : 1.48	5.09 : 1
Wild boar	Kaziranga	1 : 0.75	1.35 : 1
	Jaldapara	1 : 1	0.5 : 1

in each. During the summer season, Chitals congregate and remain for long periods in the woodlands habitats, obviously because of the abundance of shrubs.

Sex ratio and percentage

Most large mammals, particularly the ungulates, are promiscuous and can increase rapidly with five or even more females per adult male. A population with more females than males generally has a higher reproductive potential than does one that is predominantly male (Spillet 1966 b).

Sex ratio is generally an indicator of the reproduction potential of a species. A high percentage of young as compared to adults generally indicates a fast growing or thriving population. In contrast a relatively small percentage of young usually indicates a sluggish rate of population increase.

There is a higher proportion of male to female in Chital population of the Keoladeo National Park compared to that in other parks, except in Gir where it is 1:2.5 (Table 4.10) while in the case of other species of ungulates it is just the opposite, where the males are in higher proportion to females in Keoladeo National Park than in other parks. This can be explained by the hypothesis given by De and Spillet (1966) that more or less 1:1 sex ratio may usually be found in an area which is free from selective shooting or predation. While Berwick (1974) reports that proportion of lower number of male in Gir reflects on the preponderance of males in the prey of larger carnivores at Gir.

Ables (1974) working on Chital in Texas found 1.3 doe to each buck while Graf and Nicholos (1966) found 0.76:1 ratio in Hawaii.

The sex ratio of male to female of Blackbuck at Texas was 1:0.9 (Mungall 1978). In India, Daniel (1967) recorded 1:1.4 ratio at Point Calimere and he attributed this to selective poaching of males. The sex ratio at birth of North American deer according to Severinghaus and Cheatum (1956) is tilted in favour of males; 0.85 female to each male for White-tailed deer (*Odocoileus virginianus*). Robinette (1956) calculated a ratio of 0.88 female to each male for Mule deer (*Odocoileus hemionous*). The reason for disparity between the sexes has not been explained by these workers.

The ratio of female to young (all the ungulates species) during the study period at Keoladeo National Park shows that the population is stable. Sheffield *et al.* (1983) found the ratio between female to young in Nilgai was 1.23:1 while Ables (1974) working in Chital found the ratio of 2.3 female to each young. Compared to the ratio obtained from other parks there are fewer young per female in Keoladeo National Park and hence the ungulate population in the Park has been regarded as stable. But this stability inspite of the absence of the predators is deceptive. There is likelihood of progressive increase in the proportion of older individuals who are destined to die out on reaching their physical life span. If the birth rate continues to be low with the years to come the population will decline very fast.

Table 4.11

Density and biomass of wild ungulates in various national parks

Species	Park	Density per Km^2	Biomass Kg/Km^2	Authority
	Wilpattu (Sri Lanka)	12	544	Eisenbergh and Lockhart (1972)
	Chitwan (Nepal)	17.3	951	Seidensticker (1976)
Chital	Kanha	193.7	34259	Pandey et al (1986)
	Gir	3.78	172.3	Berwick (1974)
	KNP	9.79	461.2	Present study
	Wilpattu (Sri Lanka)	1.0	135	Eisenbergh and Lockhart (1972)
Sambar	Kanha	0.9	131.6	Pandey et al (1986)
	Gir	0.24	33.1	Berwick (1974)
	KNP	0.75	128.62	Present study
Blackbuck	Kanha	0.03	0.69	Pandey et al (1986)
	KNP	0.79	28.62	Present study
Nilgai	Gir	0.86	166.3	Berwick (1974)
	Vanibihar	2.35	530.3	Spillet (1966 a)
	KNP	7.0	1451.8	Present study
Wild boar	Kaziranga	0.21	31.5	Spillet (1966 b)
	Jaldapara	3.75	562.5	Spillet (1966 c)
	KNP	2.24	280.34	Present study

Density and biomass

The degree of forest cover has a strong influence on the ungulate biomass attainable for a given area. In general, the highest ungulate biomass are attained where forest and meadows or alluvial plain inter-digitate to create a maximum interdispersion of cover types (Eisenberg and Lockhart 1972).

Biomass data of the ungulates in the Asian habitat were calculated by Berwick 1974; Schaller 1967; Eisenbergh and Lockhart 1972; Mckay 1973; Seiedensticker 1976; Pandey *et al.* 1986 and Eisenbergh and Seidensticker 1976 which is summarized in Table 4.11.

It is interesting to note that the biomass per sq.km. of the wild ungulates at Keoladeo National Park surpasses that of other national park on the Indian subcontinent, (except Kaziranga -2858 Kg/Km^2) and even most other areas of the world (except Manyara in East Africa - 7785 Kg/Km^2). If feral and domestic cattle are also included in the estimation of biomass per sq.km. Keoladeo National Park will have a higher biomass per sq.km.than that of Gir and Kanha National Parks (Table 4.12).

The density and biomass (per sq.km.) of Chital and Sambar in Keoladeo National Park was comparatively lower than other parks except Gir where it exceeds. But the biomass (per sq.km.) of Nilgai in Keoladeo National Park are higher than in other parks. This may be due to the availability of extensive habitats suitable to Nilgai which prefers the ecotone area of wetland and savannah or grassland.

Table 4.12

Biomass of ungulates in several parks

Area	Biomass/Km^2	Authority
Gir	383	Berwick (1974)
Wilpattu (Sri Lanka)	766	Eisenbergh and Lockhart (1972)
Gal Ova (")	886	Mckay (1973)
Kanha	1790	Schaller (1967)
Chitwan (Nepal)	1790	Seidensticker (1976)
Jaldapara	984	Spillet (1966 c)
Kaziranga	2858	Spillet (1966 b)
Udjung Kulon (Jawa Indonesia)	492	Hoogerwerf (1970)
Manyara (East Africa)	7785	Schaller (1972)
Domestic ungulates		
Gir	6171	Berwick (1974)
Kanha	4678	Schaller (1967)
Chitwan (Nepal)	28076	Scidensticker (1976)

The biomass per sq km of all ungulates taken together excluding Feral cattle is higher compared to that in other parks (Table 4.12). Even the cattle biomass per sq km is also comparatively higher in Keoladeo National Park (11137 Kg/Km^2)than in Gir and Kanha National Parks where it is 6171 and 4678 Kg/Km^2 respectively. The high density of livestock at Chitwan reflects the higher carrying capacity of the alluvial plains at the base of the Himalayan foot hills (Eisenbergh and Seindensticker 1976). At Keoladeo National Park the high density of biomass may be due to the wetland which has the higher productivity in terms of forage as compared to the terrestrial area.

Mortality

Attempts were made to find out the possible causes of mortality. Since no parasite or any sign of disease could be noticed, these two factors did not seem to be regulating the population of wild ungulates at Keoladeo National Park.

The absence of large carnivores rules out the possibility of predation. The higher mortality in Chital was due to the predation by Pariah dog, while that of Feral cattle was due to the drought of 1988. Jackals which are present in large numbers in the park were not seen preying up on ungulates. The python which is common in the park do prey upon Chital fawns but predation is so rare that it can hardly have an impact on the ungulate population.

Exponential rate of increase

During the study period, the exponential rate of increase (r) had a positive trend for all the ungulates except Feral cattle and Wildboar. The reason for the negative 'r' value in Feral cattle is the large number of mortality that it suffered during 1988, which was the drought year. Scarcity of food was the main cause of mortality. The case for the Wild boar is almost similar. Before the present study was started, information gathered by others at the BNHS Research centre shows that there were large number of Wild boar in the Park during 1985-86. During the drought year, very few Wild boar bred. According to Baber and Colberntz (1987) extreme fluctuations in population levels of Feral pig were observed in response to availability of oak mast and drought induced changes in habitat quality. During years when oak mast is scarce and drought severe, population decline dramatically. As these habitat features required for survival diminish, reproduction ceases and animal condition deteriorates until either death occur or condition improve.

4.5 Summary

1) Census by the simultaneous and zonal count were found equally suitable for Chital, Nilgai and Feral Cattle while intensive count method proved to be better for the species with smaller populations, like Blackbuck and Sambar.

2) There is a higher proportion of male to female in Chital population of Keoladeo National Park compared to that in

other parks, but the trend is reversed in the case of other species of ungulates.

3) Exponential rate of increase `r' calculated for the study period (1987-89) shows an increasing trend for all ungulate species except Feral cattle and Wild boar. When calculated for the year 1966-89 only Nilgai and Sambar populations showed an increasing trend. In both the cases the values of increases and decreases were very low indicating stable populations of all the ungulate species of Keoladeo National Park.

4) Maximum density was of Feral cattle while the least was of Sambar. Feral cattle alone constitute 85% of biomass $/km^2$ of the total biomass of ungulates.

5. HABITAT PREFERENCE

5.1 Introduction

Quite a few studies have been done particularly in the western countries on the habitat utilization of ungulates in various parts of the world which include the work of Martinka (1968), Seal *et al.* (1978), Singer (1979), Cairns and Telfer (1980), Arbruster and Porath (1980), Collins and Urness (1981, 1983), Irwin and Peak (1983), Fedyk *et al.* (1984), Chapman *et al.* (1985), Maublanc (1986).

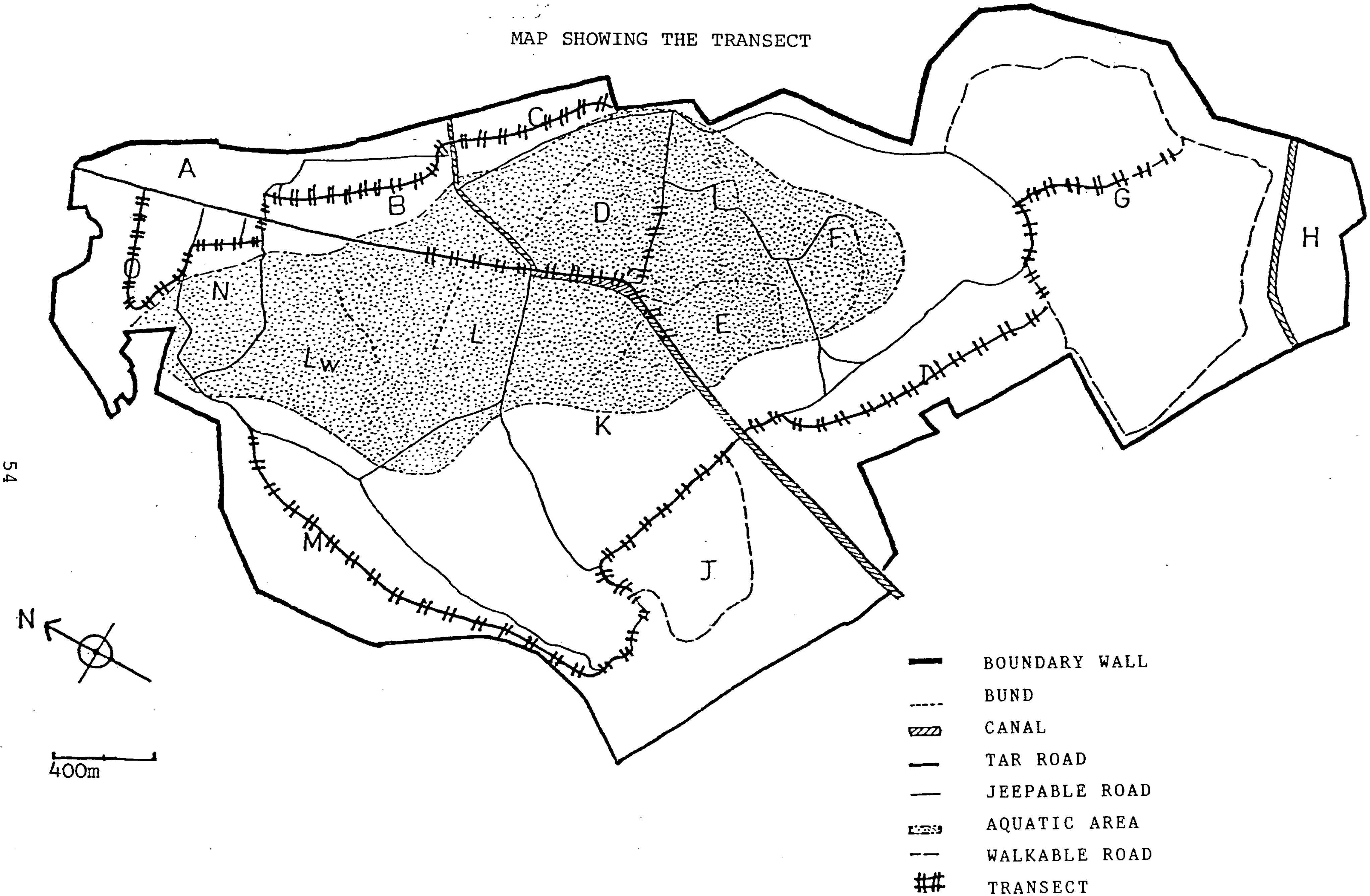
Only stray information is available on the habitat preference of Indian ungulates through the work of Martin (1977), Berwick (1974), Rice (1984), Prasad and Rao (1984), Green (1985), Balakrishnan and Easa (1986), Nair and Jayson (1988).

Habitat utilization of the following few Indian ungulates introduced to Texas were also reported. Chital was studied by Ables (1974), Blackbuck by Mungal (1978) and Nilgai by Sheffield *et al.* (1983). The relationship between habitat structure and its utilization by different herbivores has been studied in Chitwan National Park (Mishra 1982) and in Africa (Sinclair and Griffth 1979).

No detailed study has been done on the habitat preference of ungulates in the Keoladeo National Park except the preliminary observations reported by Haque (1988).

FIG 5.1

MAP SHOWING THE TRANSECT



5.2 Methodology

Visual observations were made by traversing a set transect, (Fig 5.1) that was carefully laid through all the different habitats. Studies were carried out in the following 10 habitats.

Habitat	Mnemonic
Woodland	WOOD
Scrub-woodland	SCW
Dense to discontinuous thickets	DST
Scattered shrub	SSH
Savannah woodland to scattered tree savannah	SWS
Shrub savannah	SHS
Grass savannah	GRS
Low grassland with scattered tree and shrub	LGR
Wetland	WET
Mosaic of several vegetation types	MOS

Animals were counted with the aid of a pair of 8 x 30 field glasses. The transects were traversed in different hours of the day; five times in a month. Studies were carried out from July 1987 to June 1989.

The visibility on either side of the transect was measured following the method of Hirst (1969). As a rule it was measured at every 100 m along the transect. Variation in visibility due to difference in habitat features in between the 100 m points, were measured. All these points were plotted on a map.

Table 5.1

Area covered in different habitats

Habitat	Total area in sq.km.	Area covered in sq.km.	Percentage covered
Woodland (Wood)	0.18	0.03	17
Scrub-woodland (SCW)	1.35	0.27	20
Dense to discontinuous Thickets (DST)	2.43	0.51	21
Scattered Shrub (SSH)	0.63	0.11	18
Savannah woodland to Scattered tree savannah (SWS)	6.42	1.4	22
Shrub savannah (SHS)	0.91	0.15	17
Grass savannah (GRS)	2.97	0.45	15
Low grassland with scattered tree and shrub (LGR)	3.93	1.06	27
Wetland (WET)	8.5	4.2	49
Mosaic of several types (MOS)	1.08	0.19	18

The visibility was found to vary from 5 to 500 m, depending upon the habitat features. Only certain part of each habitat was covered by walking on the transects. The area scanned while walking along the transects and its ratio to the total area of the habitat type are given in Table 5.1.

Whenever any ungulate species was spotted details of the habitat were noted and, thereafter, the animal was watched for as long as possible. The following information was recorded at each encounter: date, time, location, the percentage cover of the tree canopy, shrub layer and herb layer.

Density of each ungulate species in every habitat was computed for each month, but most of the analyses were done on seasonal basis.

5.2.1 Vegetation cover

Whenever, any animal was sighted, different vegetation cover (such as tree, shrub and herb) were recorded at the radius of 10 m to know the preference for different vegetation cover during different hours of the day and during different seasons.

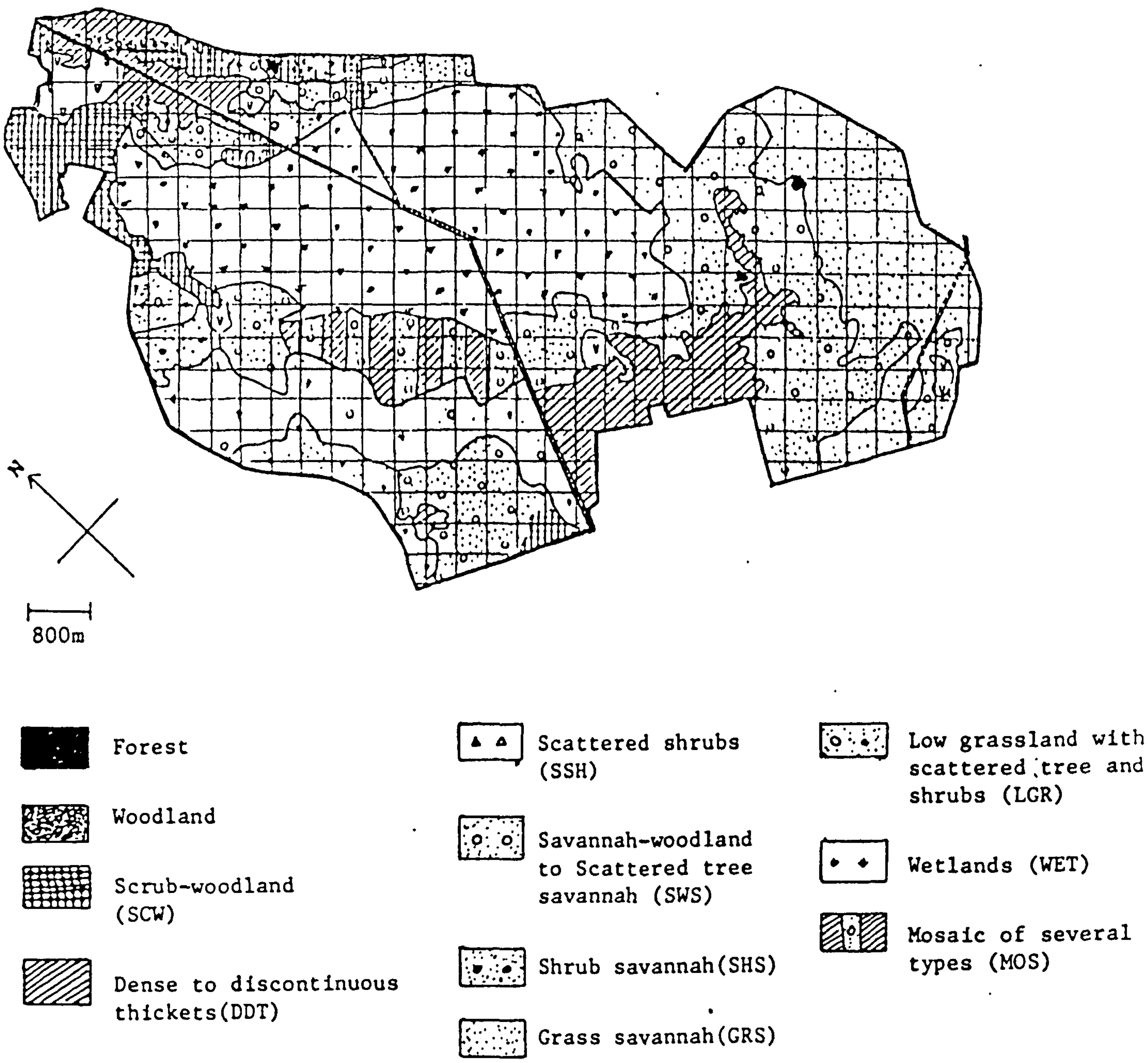
5.2.2 Availability of crown area

The crown area of tree and shrub were measured by two different types of plots.

(a) Quadrates of 15 x 15 m were laid along either side of the transect (described earlier under methodology) at an intervals of

FIG 5.2

DISTRIBUTION OF THE MAIN PHYSIOGNOMIC TYPES IN THE PARK



100 m to estimate the crown areas of trees and shrubs available to the animals along the whole transect. All the trees and shrubs in each quadrate were counted and their crown areas were measured. The crown area in the plots was estimated by the measuring the length and width of the crown of each tree and shrub present in the plot.

(b) Grids of 400 m x 400 m (Fig 5.2) covering the entire Park were laid and 150 intersections of the transects were selected for a detailed study which is given in later chapter. Circular sample plots were demarcated at these intersections. The crown area of trees and shrubs were measured in each circular plot of eight meter radius. The data from all such sample plots located in each habitat type was separately pooled. the average areas covered by tree and shrub crown per 200 m^2 was then calculated.

5.2.3 Statistical analysis

The following statistical analysis were done using mainly the statistical packages.

Preference

The preference assessment programme, PREFER, described by Johnson (1980) has been used to determine the preference of J individual for I components using availability and usage data. PREFER tests the hypothesis that all components are equally preferred and compares components using the multiple comparison procedure of Waller and Duncan (1969).

Prefer consists of the following three parts :

i) The first section lists the mean difference in ranks for each component. Components are listed from the most preferred to least preferred.

ii) The 'F' statistic for testing the hypothesis of equal preference is given, followed by 'W', the critical value for the Waller-Duncan using a 'K' ratio of 100. The details derivation of the formula used are described by Johnson (1980).

iii) The final section lists the following statistics for each pair of components 'I' and 'K'.

V_{ik} - the covariance

d_{ik} - the difference in mean rank

d_{ik}/Sd_{ik} - The absolute standard difference in mean rank (Sdik is the standard error of the difference)

If $d_{ik} < 0$, a preference is shown for component 'I' over component 'K'. If on the other hand $d_{ik} > 0$, a preference is shown for component 'K' over component 'I'. If $d_{ik}/Sd_{ik} > W$ the preference is statistically significant.

For analysis, only those habitat have been taken into consideration in which the animal was seen. According to Johnson (1980) it is readily seen that the question of inclusion/exclusion is germane in this application.

Analysis of variance

Two factor analysis of variance test was done for all the ungulates to find out whether there is any seasonal difference in preference of habitats.

Kruskal Wallis one way analysis of variance

This test was done to find out whether there is any significant difference in the utilization of vegetation cover (tree, shrub, herb) during different hours and different season. The data for different hours were pooled together into four broad day light hours such as 0600-0800, 0900-1100, 1200-1400 and 1500-1800 hours.

Pearson-correlation coefficient

The similarity in habitat utilization by different species in different season was calculated using cluster analysis (Pielou 1984) and Pearson correlation coefficient.

Niche Breadth

Niche breadth of each species were calculated applying the following formula

$$\text{Niche breadth} = B = 1/\Sigma Pi^2$$

$$Bn = B-1/N-1 \quad \text{(Levins 1968)}$$

5.3 Result

5.3.1 Habitat preference

CHITAL

All the nine different habitat types have been ranked according to the intensity of utilization by Chital. This ranking is base on (a) the area of each habitat type and (b) the number of animals found occupying it. When the two values (a) and (b) are integrated we get an objective idea of relative utilization of each habitat type which is expressed in terms of rank. Lower the figure of mean difference between the ranks of usage and the rank of availability, higher is the rank and vice versa. According to this scheme scrub woodland ranks highest in terms of preference (-2.375) followed by scattered shrub (-1.958). The wetland habitat ranks the lowest (4.458) (Table 5.2).

All the habitat components appeared not to be used with equal intensity (F value 71.11 with df 8, 4).

The critical value for Waller Duncan (W = 2.63) was compared with Absolute standard difference to determine the significance of difference in preference between the different habitats (Table 5.2). The highest absolute standard difference was 14.92 in between wetland and scrub woodland and the least was between low grassland and mosaic of several types.

The habitat utilization by Chital significantly varied from one to the other type and also seasonally. The utilization of

Table 5.2

Significance test for habitat preference of Chital

AVERAGE DIFFERENCE IN RANKS FOR HABITATS

HABITAT	TBAR	RANK	HABITAT	TBAR	RANK
SCW	-2.375000	1	LGR	.208333	6
SSH	-1.958333	2	MOS	.375000	7
WOOD	-1.458333	3	GRS	2.166667	8
DST	-1.333333	4	WET	4.458333	9
SWS	-.083333	5			

TEST OF HO: ALL HABITATS ARE EQUALLY PREFERRED

F (8, 4) = 71.11736

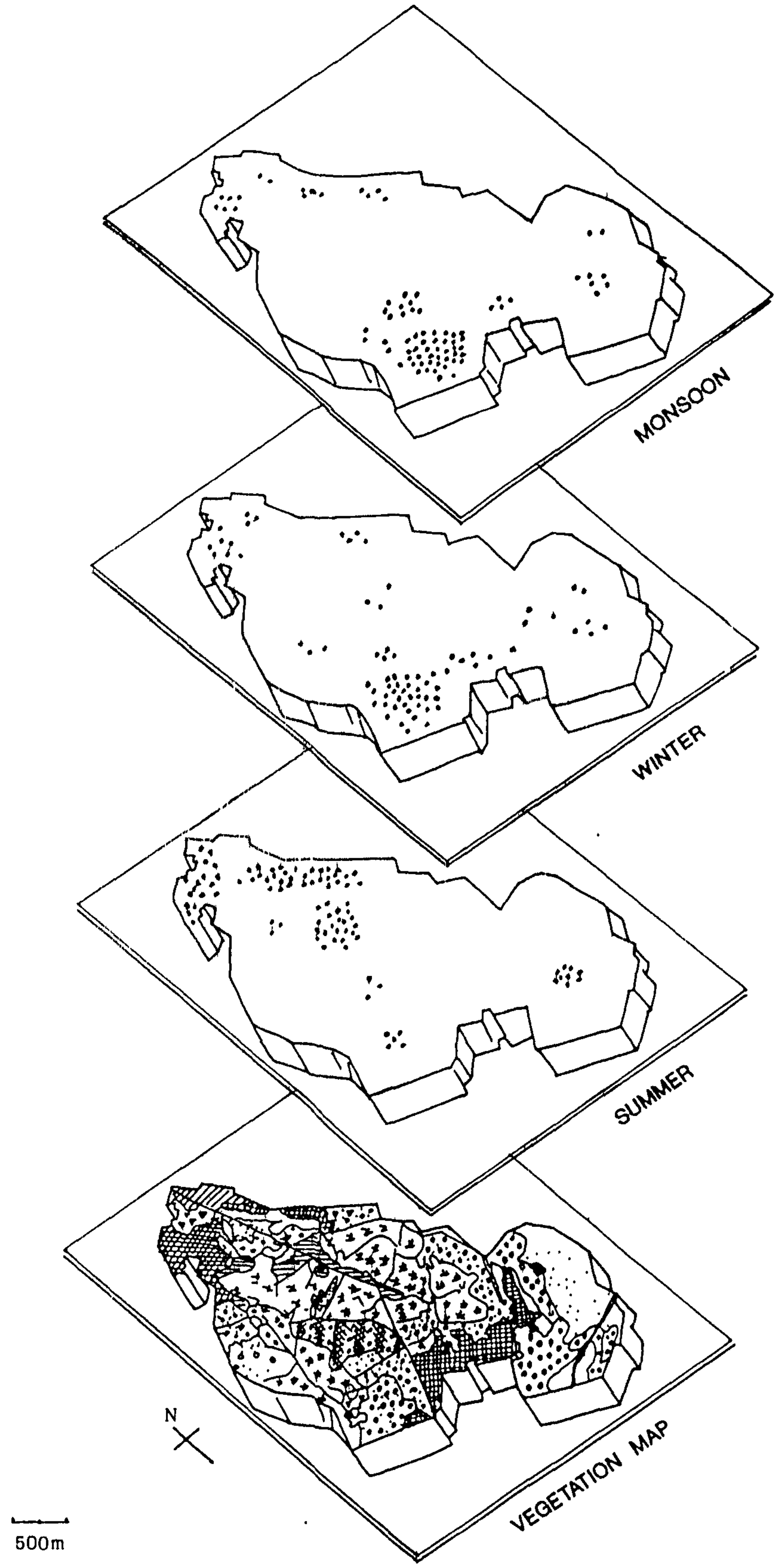
THE CRITICAL VALUE FOR THE WALLER-DUNCAN PROCEDURE
WITH K = 100. IS W = 2.63

I	K		VARIANCE/ COVARIANCE	DIFFERENCE IN MEAN RANK	ABSOLUTE STANDARD DIFFERENCE
SCW	SCW		3.36932	.00000	.00000
DST	SCW	SIG	1.22727	1.04167	2.62860
DST	DST		.96970	.00000	.00000
SWS	SCW	SIG	-.94318	2.29167	3.22315
SWS	DST		-.57576	1.25000	2.52890
SWS	SWS		.81061	.00000	.00000
LGR	SCW		-3.71023	2.58333	2.13967
LGR	DST		-1.42424	1.54167	1.64648
LGR	SWS		1.06439	.29167	.43542
LGR	LGR		6.70265	.00000	.00000
WET	SCW	SIG	1.89205	6.83333	14.92592
WET	DST	SIG	.34849	5.79167	11.21087
WET	SWS	SIG	-.04924	4.54167	8.02964
WET	LGR	SIG	-2.69508	4.25000	3.79844
WET	WET		2.92992	.00000	.00000
GRS	SCW	SIG	-.47727	4.54167	6.69582
GRS	DST	SIG	-.34848	3.50000	7.16473
GRS	SWS	SIG	.33333	2.25000	6.73091
GRS	LGR	SIG	1.28030	1.95833	2.93594
GRS	WET	SIG	-.78788	-2.29167	3.32433
GRS	GRS		1.19697	.00000	.00000
SSH	SCW		-.34659	.41667	.63177
SSH	DST		.19697	-.62500	1.64466
SSH	SWS	SIG	-.35985	-1.87500	3.96203
SSH	LGR	SIG	-.05492	-2.16667	2.65865
SSH	WET	SIG	-1.15720	-6.41667	8.78534
SSH	GRS	SIG	-.28030	-4.12500	8.36975
SSH	SSH		1.15720	.00000	.00000
MOS	SCW	SIG	-2.00568	2.75000	3.05799
MOS	DST	SIG	-.68182	1.70833	2.74221
MOS	SWS		.30682	.45833	1.00000
MOS	LGR		1.16477	.16667	.22310
MOS	WET	SIG	-.96023	-4.08333	5.28102
MOS	GRS	SIG	-.36364	-1.79167	3.01127
MOS	SSH	SIG	.36932	2.33333	4.88090
MOS	MOS		2.32386	.00000	.00000
WOOD	SCW		.99432	.91667	1.90960
WOOD	DST		.28788	-.12500	.32470
WOOD	SWS		-.58712	-1.37500	2.59491
WOOD	LGR		-2.32765	-1.66667	1.61738
WOOD	WET	SIG	.47917	-5.91667	11.18801
WOOD	GRS	SIG	-.55303	-3.62500	6.53932
WOOD	SSH		.47538	.50000	1.37321
WOOD	MOS	SIG	-.15341	-1.83333	3.16943
WOOD	WOOD		1.38447	.00000	.00000

TBAR = Mean difference between the ranks of usage and the rank of availability

FIG 5.3

SEASONAL DISTRIBUTION OF CHITAL



Forest	Scattered shrubs	Wetlands
Woodland	Shrub savannah	Mosaic of several types
Scrub-woodland	Grass savannah	Plantations in wetlands
Savannah-woodland to Scattered tree savannah	Low grassland with scattered tree and shrubs	Dense to discontinuous thickets

different habitats shows a higher variation ($P < 0.001$) than seasonal variation ($P < 0.02$) (Table 5.8).

During monsoon Chital were mostly seen in LGR, DST and MOS habitat, whereas in winter it was seen in LGR and SCW. While during summer it mainly utilizes shrub dominated areas like SCW and DST habitat when most of the grasses dries up in other habitats type (Fig 5.3).

SAMBAR

Sambar utilized only four habitats, but the animals were seen mostly in the wetland area than in other habitats (Plate 5). The statistical analysis however shows that MOS was the most preferred habitat (Table 5.3). This may be due to the fact that MOS habitat has smaller area and hence a higher density of animals.

The 'F' value of the habitat utilization is highly significant ($P < 0.001$) leading to the inference that all the habitats are not utilized with equal proportion.

The absolute standard difference was maximum (17.23) between MOS and SWS while it was minimum (0.357) between WET and SWS (Table 5.3). All the habitat combinations show significant difference in utilization except between WET and SWS.

The analysis of variance for Sambar (Table 5.8) shows that there was significant seasonal ($P < 0.05$) and habitat ($P < 0.005$) variation. Most of the animals moved towards the terrestrial

Table 5.3

Significance test for habitat preference of Sambar

AVERAGE DIFFERENCE IN RANKS FOR HABITATS

HABITAT	TBAR	RANK
MOS	-1.45833	1
DST	-.291667	2
SWS	.791667	3
WET	.958333	4

TEST FOR HO: ALL HABITATS ARE EQUALLY PREFERRED
F (3, 9) = 1707.028

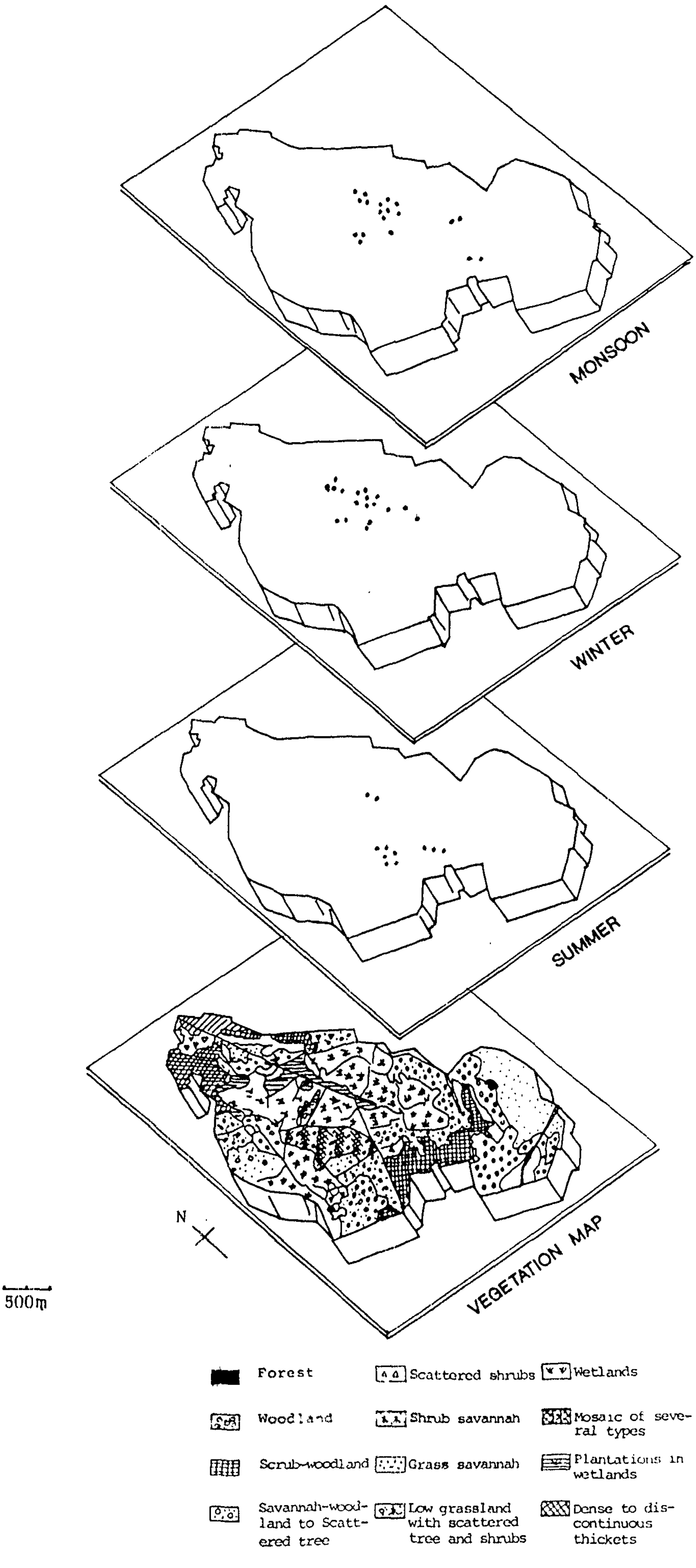
THE CRITICAL VALUE FOR THE WALLER-DUNCAN PROCEDURE
WITH K=100 IS W=250

I	K		VARIANCE/ COVARIANCE	DIFFERENCE IN MEAN RANK	ABSOLUTE STANDARD DIFFERENCE
DST	DST		.79356	.00000	.00000
SWS	DST	SIG	-.24811	1.08333	3.02616
SWS	SWS		.24811	.00000	.00000
WET	DST	SIG	-.08144	1.25000	2.80306
WET	SWS		-.46402	.16667	.35764
WET	WET		1.42992	.00000	.00000
MOS	DST	SIG	-.46402	-1.16667	2.50349
MOS	SWS	SIG	.46402	-2.25000	17.23370
MOS	WET	SIG	-.88447	-2.41667	4.14286
MOS	MOS		.88447	.00000	.00000

TBAR = Mean difference between ranks of usage and the rank of availability

FIG 5.4

SEASONAL DISTRIBUTION OF SAMBAR



area from aquatic area as the latter gets dried up during summer. MOS and DST types were mainly utilized in the terrestrial areas (Fig 5.4).

BLACKBUCK

Blackbuck had been observed to have a clear preference for LGR habitat, followed by SWS habitat (Table 5.4). It was found in the wetland only when it dried up during summer and was no more a wetland. These areas were bulldozed during summer to remove the grasses and, soon after rain, the whole area was covered with fresh sprout. Since this area was not filled with water, Blackbuck utilized it for grazing, and the mound, created by the sprils of bulldozing, for resting. Its presence in that area should therefore not be regarded as preference for wetland.

The 'F' value (47.615) shows that all the three habitats were not utilized with equal intensity and the significance test between the habitats shows that LGR habitat varied with both SWS and WET but SWS did not very much with WET.

Although there was not much seasonal variation in the utilization of each habitat it varied from one to other habitat. (Table 5.8).During all the three season viz; monsoon, winter and summer Blackbuck mainly utilizes LGR though it was seen utilizing SWS and WET (dried up) during summer (Fig 5.5).

NILGAI

Like Chital, Nilgai also utilized nine habitats. The average difference in ranks was least in Scattered shrub (-1.12)

Table 5.4

Significance test for habitat preference of Blackbuck

AVERAGE DIFFERENCE IN RANKS FOR HABITATS

HABITAT	TBAR	RANK
LGR	-1.666667	1
WET*	.791667	2
SWS	.875000	3

* Only when wetland dried up

TEST OF HO: ALL HABITATS ARE EQUALLY PREFERRED

F (2, 10) = 47.61538

THE CRITICAL VALUE FOR THE WALLER-DUNCAN PROCEDURE
WITH K = 100. IS W = 2.07

I	K		VARIANCE/ COVARIANCE	DIFFERENCE IN MEAN RANK	ABSOLUTE STANDARD DIFFERENCE
SWS	SWS		.09659	.00000	.00000
LGR	SWS	SIG	-.13636	-2.54167	9.88369
LGR	LGR		.42424	.00000	.00000
WET	SWS		.03977	-.08333	.56061
WET	LGR	SIG	-.28788	2.45833	7.62264
WET	WET		.24811	.00000	.00000

TBAR = Mean difference between the ranks of usage and the rank of availability

FIG 5.5

SEASONAL DISTRIBUTION OF BLACKBUCK

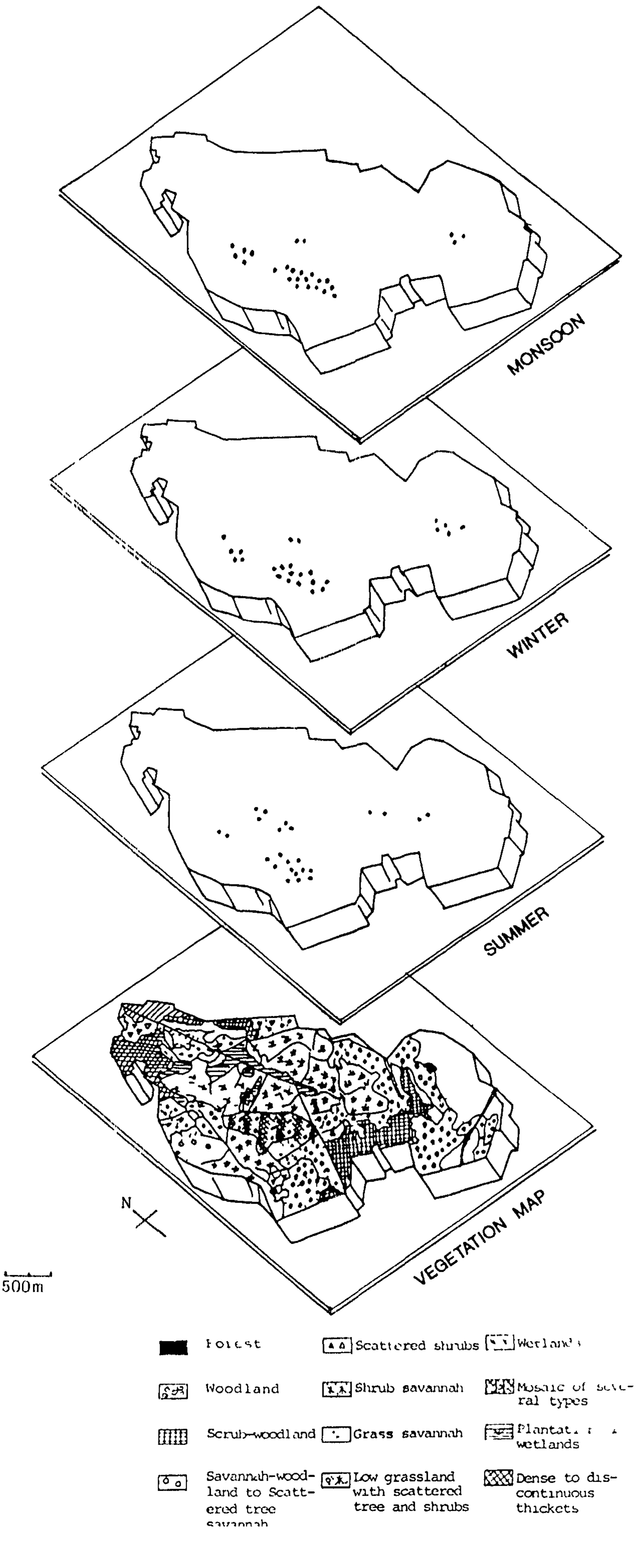


Table 5.5

Significance test for habitat preference of Nilgai

AVERAGE DIFFERENCE IN RANKS FOR HABITATS

HABITAT	TBAR	RANK	HABITAT	TBAR	RANK
SSH	-1.125000	1	LGR	.208333	6
SHS	-.875000	2	MOS	.708333	7
SWS	-.833333	3	WET	1.083333	8
SCW	-.291667	4	GRS	1.416667	9
DST	-.291667	5			

TEST OF H0: ALL HABITATS ARE EQUALLY PREFERRED

F (8, 4) = 5.54299

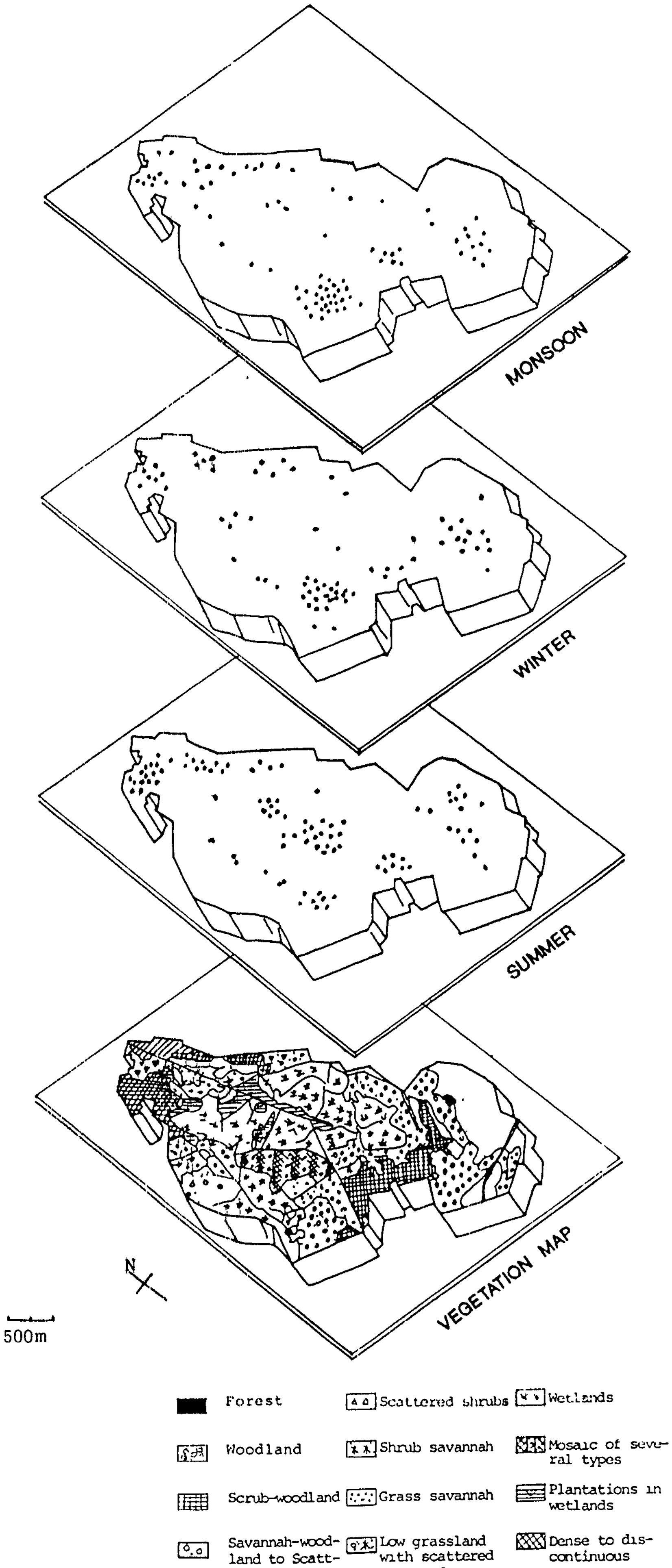
THE CRITICAL VALUE FOR THE WALLER-DUNCAN PROCEDURE
WITH K = 100. IS W = 2.85

I	K		VARIANCE/ COVARIANCE	DIFFERENCE IN MEAN RANK	ABSOLUTE STANDARD DIFFERENCE
SCW	SCW		1.52083	.00000	.00000
DST	SCW		.17992	.00000	.00000
DST	DST		.20265	.00000	.00000
SWS	SCW		-.12879	-.54167	1.35068
SWS	DST	SIG	.05303	-.54167	3.76707
SWS	SWS		.15152	.00000	.00000
LGR	SCW		-.22917	.50000	1.00766
LGR	DST		-.34280	.50000	1.26876
LGR	SWS	SIG	-.03788	1.04167	3.29041
LGR	LGR		.97538	.00000	.00000
WET	SCW	SIG	.04924	1.37500	3.44219
WET	DST	SIG	-.04167	1.37500	5.39870
WET	SWS	SIG	-.19697	1.91667	6.51724
WET	LGR		-.26894	.87500	2.14027
WET	WET		.49242	.00000	.00000
GRS	SCW	SIG	-.00379	1.70833	2.93470
GRS	DST	SIG	.33712	1.70833	4.11688
GRS	SWS	SIG	-.07576	2.25000	4.62428
GRS	LGR		-.43561	1.20833	1.99903
GRS	WET		-.08333	.33333	.64580
GRS	GRS		2.53788	.00000	.00000
SSH	SCW		-.47159	-.83333	1.31928
SSH	DST		-.15341	-.83333	1.71499
SSH	SWS		.20455	-.29167	.70288
SSH	LGR	SIG	.34659	-1.33333	2.86113
SSH	WET	SIG	-.23864	-2.20833	4.21524
SSH	GRS	SIG	-1.76136	-2.54167	3.04068
SSH	SSH		2.32386	.00000	.00000
SHS	SCW		-.11932	-.58333	1.43158
SHS	DST	SIG	-.00568	-.58333	3.02251
SHS	SWS		.02273	-.04167	.24790
SHS	LGR	SIG	-.16477	-1.08333	3.02616
SHS	WET	SIG	.12500	-1.95833	9.83914
SHS	GRS	SIG	-.32955	-2.29167	4.28647
SHS	SSH		.15341	.25000	.57735
SHS	SHS		.23295	.00000	.00000
MOS	SCW		-.79735	1.00000	1.66702
MOS	DST		-.22917	1.00000	2.53752
MOS	SWS	SIG	.00758	1.54167	4.61518
MOS	LGR		.15720	.50000	1.26876
MOS	WET		.16288	-.37500	1.11012
MOS	GRS		-.18561	-.70833	1.21008
MOS	SSH	SIG	-.40341	1.83333	3.05085
MOS	SHS	SIG	.08523	1.58333	4.87631
MOS	MOS		1.20265	.00000	.00000

TBAR = Mean difference between the ranks of usage and the rank of availability

FIG 5.6

SEASONAL DISTRIBUTION OF NILGAI



which appears to be the most preferred habitat whereas, the maximum was in GRS (1.41) showing it to be the least preferred habitat (Table 5.5).

The 'F' (5.54) with df (8, 4) indicates that all the habitats are utilized with equal intensity.

The highest absolute standard difference was 9.83 between SHS and WET components while the least was 0.57 between SHS and SSH (Table 5.5).

Although there was not much seasonal variation in the utilization of each habitat it significantly varied from one to the other habitat (Table 5.8).

Nilgai were seen in all the habitat types throughout the year. But during monsoon and winter it mainly utilizes LGR, SCW, DST and SWS while during summer besides these habitats they were also seen in WET habitat (Fig 5.6).

FERAL CATTLE

Altogether nine habitats were seen used by the Feral cattle. The most preferred habitat was SSH followed by LGR and the least preferred was WET (Table 5.6).

As in the case of Nilgai, 'F' value (3.84) with (8, 4) did not vary significantly and hence, all the habitats were utilized with equal intensity.

Table 5.6

Significance test for habitat preference of Feral cattle

AVERAGE DIFFERENCE IN RANKS FOR HABITATS

HABITAT	TBAR	RANK	HABITAT	TBAR	RANK
SSH	-1.583333	1	MOS	.125000	6
LGR	-1.333333	2	SWS	.166667	7
SHS	-.541667	3	GRS	1.500000	8
DST	-.166667	4	WET	1.708333	9
SCW	.125000	5			

TEST OF HO: ALL HABITATS ARE EQUALLY PREFERRED

F (8, 4) = 3.84218

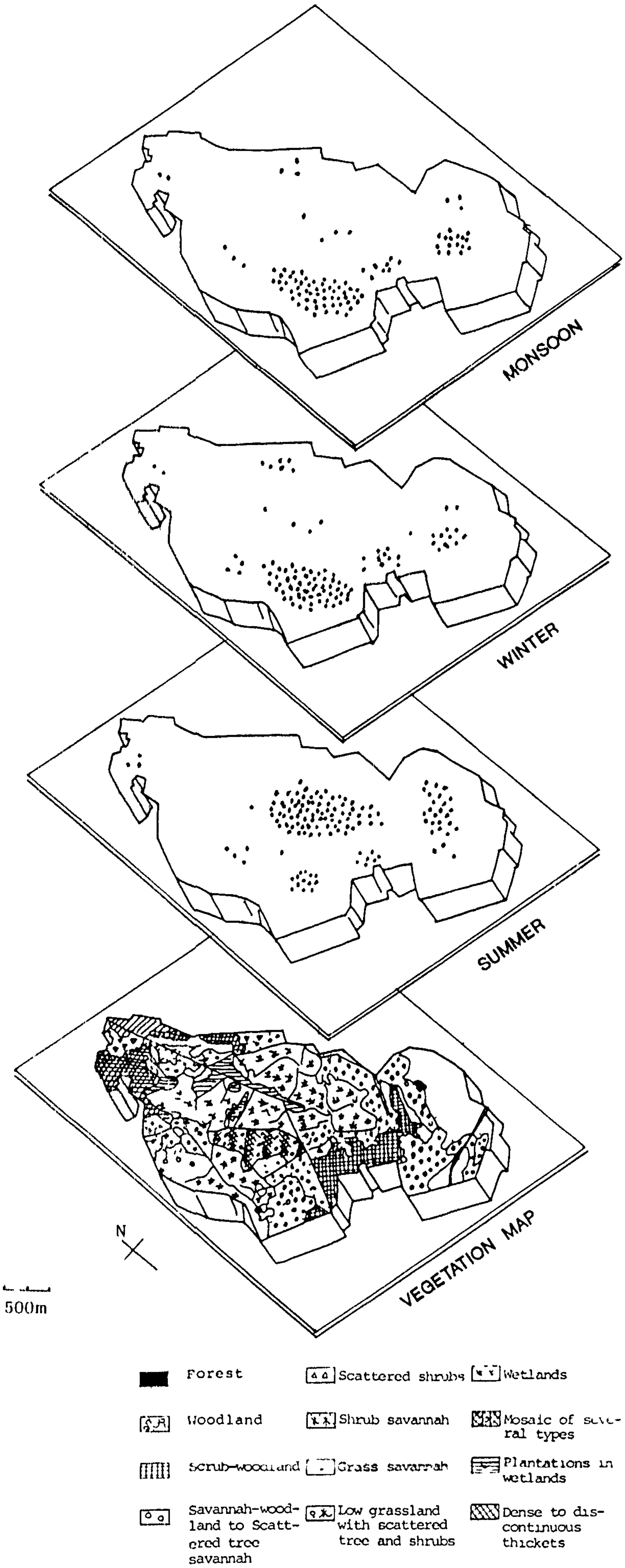
THE CRITICAL VALUE FOR THE WALLER-DUNCAN PROCEDURE
WITH K = 100. IS W = 2.85

I	K		VARIANCE/ COVARIANCE	DIFFERENCE IN MEAN RANK	ABSOLUTE STANDARD DIFFERENCE
SCW	SCW		1.46023	.00000	.00000
DST	SCW		-.29545	-.29167	.65431
DST	DST		.33333	.00000	.00000
SWS	SCW		-.02273	.04167	.11212
SWS	DST		.03030	.33333	1.77281
SWS	SWS		.15152	.00000	.00000
LGR	SCW	SIG	.45455	-1.45833	4.36571
LGR	DST	SIG	.12121	-1.16667	4.31117
LGR	SWS	SIG	.06061	-1.50000	5.74456
LGR	LGR		.78788	.00000	.00000
WET	SCW		-.68750	1.58333	2.13767
WET	DST		-.64394	1.87500	2.80306
WET	SWS		-.31061	1.54167	2.51172
WET	LGR	SIG	-1.24242	3.04167	3.97656
WET	WET		3.74811	.00000	.00000
GRS	SCW		-.40909	1.37500	2.14853
GRS	DST	SIG	.04545	1.66667	3.40279
GRS	SWS		-.27273	1.33333	2.52982
GRS	LGR	SIG	-.36364	2.83333	4.81709
GRS	WET		1.00000	-.20833	.34466
GRS	GRS		2.63636	.00000	.00000
SSH	SCW	SIG	-.46591	-1.70833	2.96807
SSH	DST	SIG	.12121	-1.41667	3.79271
SSH	SWS	SIG	.10606	-1.75000	4.91267
SSH	LGR		-.03030	-.25000	.55535
SSH	WET	SIG	-.16288	-3.29167	4.79409
SSH	GRS	SIG	-1.52273	-3.08333	3.96268
SSH	SSH		1.58333	.00000	.00000
SHS	SCW		.46023	-.66667	1.55807
SHS	DST		.21970	-.37500	1.04303
SHS	SWS		.09848	-.70833	1.93277
SHS	LGR		.21212	.79167	1.92916
SHS	WET		-1.62689	-2.25000	2.64873
SHS	GRS		-1.27273	-2.04167	2.70445
SHS	SSH		.67803	1.04167	2.62860
SHS	SHS		1.65720	.00000	.00000
MOS	SCW		-.49432	.00000	.00000
MOS	DST		.06818	.29167	.95824
MOS	SWS		.15909	-.04167	.16688
MOS	LGR	SIG	.00000	1.45833	3.87155
MOS	WET		-.07386	-1.58333	2.50071
MOS	GRS		.15909	-1.37500	2.64907
MOS	SSH	SIG	-.30682	1.70833	3.35476
MOS	SHS		-.42614	.66667	1.24801
MOS	MOS		.91477	.00000	.00000

TBAR = Mean difference between the ranks of usage and the rank of availability

FIG 5.7

SEASONAL DISTRIBUTION OF FERAL CATTLE



Among the habitat types compared for significant difference, the variation was noticed only in SSH and LGR while DST differed only with GRS (Table 5.6). The maximum absolute standard difference was noticed between LGR and SWS (5.74), whereas, minimum was between SWS and SCW (0.11).

There was significant seasonal and habitat variation in the utilization of the habitat of Feral cattle (Table 5.8).

During monsoon and winter Feral cattle were seen mainly in LGR habitat while during summer they were seen mainly utilizing SWS, LGR, WET and GRS habitat type (Fig 5.7).

<u>WILD BOAR</u>

Wild boar was found using only four types of habitats. The most preferred was DST followed by SCW and LGR. The least preferred one was SWS (Table 5.7).

The 'F' value was highly significant ($P < 0.001$) indicating that all the habitats were not used with equal intensity.

Statistical analysis shows that utilization of all the possible habitat combination were significantly different except LGR and SWS which did not differ (Table 5.7).

There was no seasonal variation in the utilization of habitat (Fig 5.8) but the utilization varied significantly among the habitats (Table 5.8).

Table 5.7

Significance test for habitat preference of Wild boar

AVERAGE DIFFERENCE IN RANKS FOR HABITATS

HABITAT	TBAR	RANK
DST	-1.916667	1
SCW	-1.208333	2
LGR	1.083333	3
SWS	2.041667	4

TEST OF HO: ALL HABITATS ARE EQUALLY PREFERRED

F (3, 9) = 580.41880

THE CRITICAL VALUE FOR THE WALLER-DUNCAN PROCEDURE
WITH K = 100. IS W = 2.50

I	K		VARIANCE/ COVARIANCE	DIFFERENCE IN MEAN RANK	ABSOLUTE STANDARD DIFFERENCE
SCW	SCW		.42992	.00000	.00000
DST	SCW	SIG	.06439	-.70833	4.21423
DST	DST		.03788	.00000	.00000
SWS	SCW	SIG	-.14962	3.25000	9.56171
SWS	DST	SIG	.04167	3.95833	17.53148
SWS	SWS		.65720	.00000	.00000
LGR	SCW	SIG	-.34470	2.29167	5.40502
LGR	DST	SIG	-.14394	3.00000	8.89944
LGR	SWS		-.54924	-.95833	1.98622
LGR	LGR		1.03788	.00000	.00000

TBAR = Mean difference between the ranks of usage and
the rank of availability

FIG 5.8

SEASONAL DISTRIBUTION OF WILD BOAR

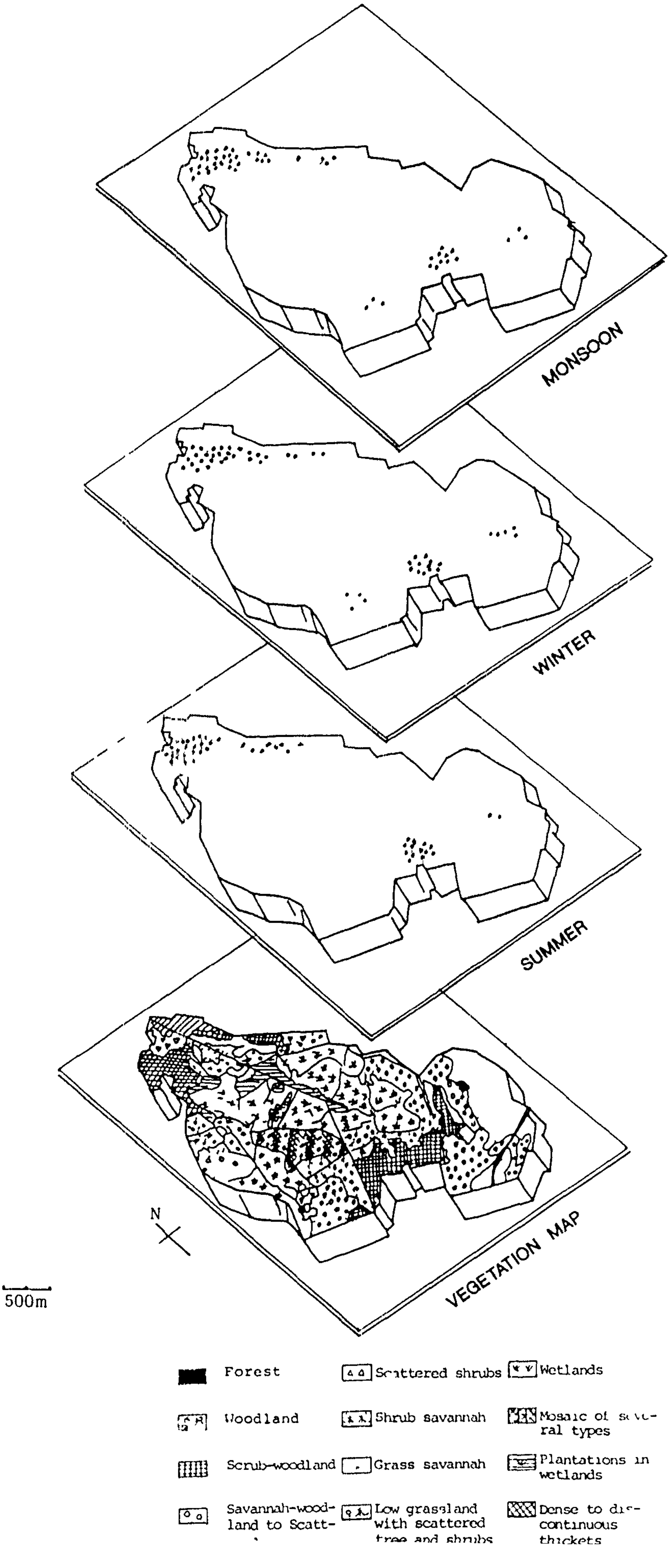


Table 5.8

Two factor analysis of variance test on various ungulate habitat preference

	Source	Sum of squares	DF	Mean-square	F-ratio	P
Chital	Season	498.357	2	249.178	4.257	0.017
	Habitat	14321.674	9	1591.297	27.184	0.000
	Season* Habitat	10622.068	18	590.115	10.081	0.000
Sambar	Season	2.451	2	1.225	3.189	0.053
	Habitat	5.785	3	1.928	5.018	0.005
	Season* Habitat	19.518	6	3.253	6.465	0.000
Blackbuck	Season	16.396	2	8.198	6.334	0.006
	Habitat	109.662	2	54.831	42.363	0.000
	Season* Habitat	38.095	4	9.524	7.358	0.000
Nilgai	Season	20.660	2	10.330	1.205	0.305
	Habitat	758.112	8	94.764	11.050	0.000
	Season* Habitat	351.143	16	21.946	2.559	0.003
Feral cattle	Season	561.296	2	280.648	5.388	0.006
	Habitat	21846.581	8	2730.823	52.425	0.000
	Season* Habitat	5895.795	16	368.487	7.074	0.000
Wild boar	Season	19.187	2	9.593	2.200	0.125
	Habitat	413.308	3	137.769	31.599	0.000
	Season* Habitat	15.838	6	2.840	0.605	0.724

5.3.2 Vegetation cover used by different ungulates

Chital

The seasonal use of the three vegetation layers, namely tree, shrub and herb varied significantly. The tree were used the maximum during summer mainly as cover to get protection from the scorching sun while, the herb layer was utilized as food mainly during the monsoon season, which is the growth period of most of the herbs.

Chital widely used most tree and also shrubs as cover in the afternoon which was significant in both the cases. The

correlation between the schedule and duration use of herb cover was not found to vary (Fig 5.9).

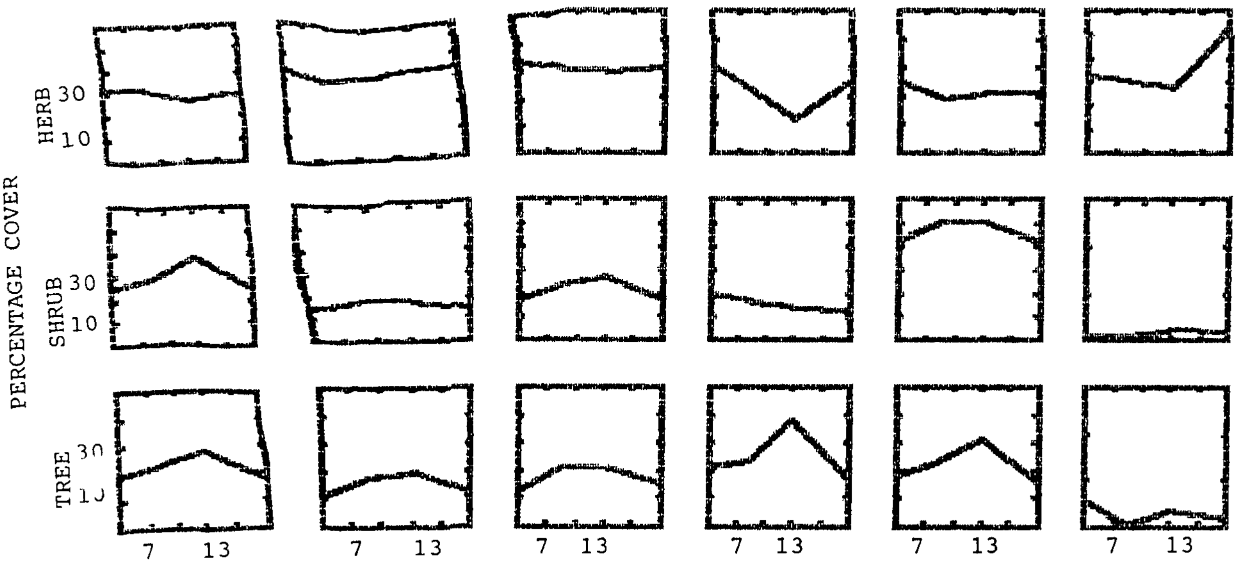
Sambar

Significant seasonal variation in the use of shrub and herb layers was observed (Fig 5.10). Sambar were seen most of the year in the aquatic area which has scanty tree cover and hence no significant variation in the tree use could be made out.

The tree cover was used mostly during the afternoon while shrubs and herbs during early hours of the day. There was no significant variation in the hourly use of various vegetation layers.

FIG 5.9

Average values of (a) Chital, (b) Feral Cattle, (c) Nilgai, (d) Sambar, (e) Wild Boar and (f) Blackbuck association with various types of vegetation cover during different hours of the day.



	A	B	C	D	E	F
TREE	18.46***	14.48**	18.61***	4.66	9.81*	10.05**
SHRUB	21.37***	4.7	19.87***	0.15	4.31	4.98
HERB	4.59	0.66	6.45*	6.96	0.95	0.19

Values of X^2 are based on the Kruskal-Wallis test (*$P < 0.05$, **$P < 0.01$, ***$p < 0.001$)

Blackbuck

The seasonal use of the different layers of vegetation by Blackbuck varied significantly only in the case of herb layer (Fig 5.10). The average value in the case of herb layer rose to a peak (39.9%) in monsoon and declined in summer (13.91%).

The average value of Blackbuck preference for tree and shrub cover during different hours of the day was very low compared to that by other ungulates. This is due to the Blackbuck particular preference for the open plain grassland habitat almost devoid of any tree and shrub. The hourly use of all the three layers did not vary significantly.

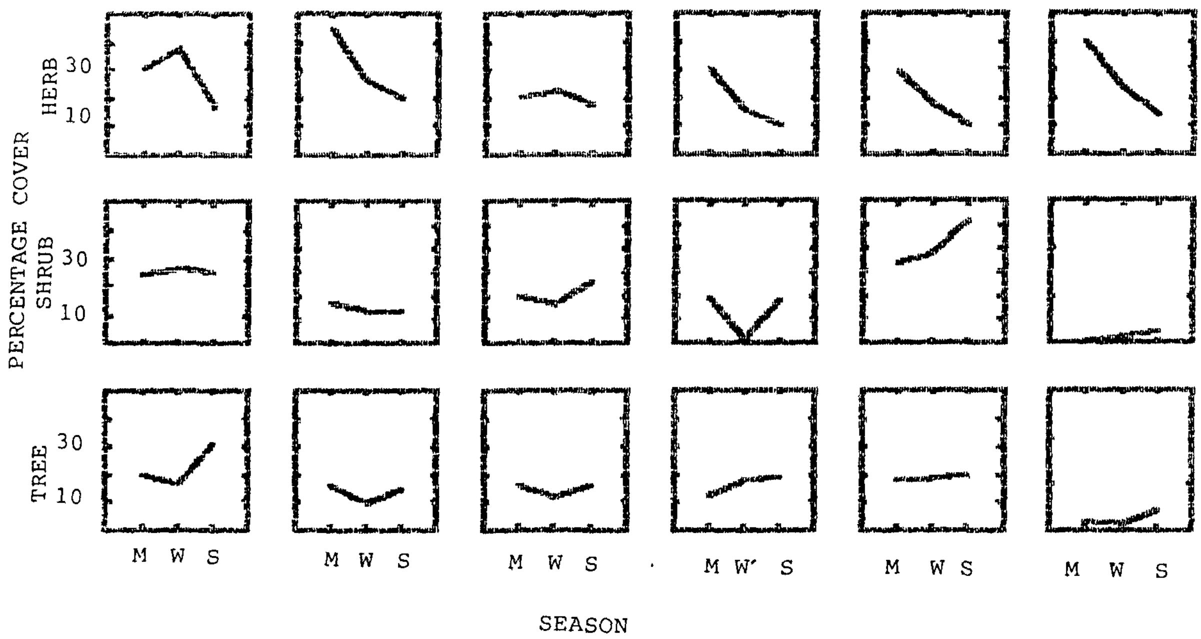
Nilgai

The seasonal use by Nilgai of the tree and herb layer of the vegetation was significantly ($P < 0.001$) higher than that of the shrub layer ($P < 0.05$). As in the case of Chital, the use of tree and shrub layer by nilgai was maximum during summer and that of herb layer during monsoon (Fig 5.10).

The use of tree and shrub layer showed significant variation in different hours, whereas, that of herb layer did not vary significantly during different hours. The maximum use of tree and shrub was during afternoon hours while herb was used during early mornings and evenings.

FIG 5.10

Average values of (a) Chital, (b) Feral Cattle, (c) Nilgai, (d) Sambar, (e) Wild Boar and (f) Blackbuck association with various types of vegetation cover during different seasons.



TREE	33.24***	0.06	52.43***	4.74*	0.26	0.14
SHRUB	33.61***	9.16**	5.66*	10.7**	22.77***	2.77
HERB	135.01***	127.61***	226.87***	14.71***	65.00***	43.68***

Values of X^2 are based on the Kruskal-Wallis test (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$)

Feral cattle

The trend of the use of different layers of vegetation for the Feral cattle was somewhat different from that of Chital and Nilgai.

Feral cattle have been found more versatile in their use of habitat for different purposes. They use trees mainly for shelter particularly during monsoon but also from sun during summer. the lowest layer layer of vegetation (i.e. herbs and grasses) is used mainly as food. Tree and shrub layers are marginally used as food and that too during the period of scarcity of other foods.

Significant seasonal variation in the use of herb and shrub layers of vegetation had been observed but not much variation in the use of tree layer (Fig 5.10). The apparent reason for the higher use of shrub layer during monsoon season is the abundance of shrubs on the saline patches and elevated portions of the habitat where Feral cattle spend most of the time when some parts of the terrestrial area get flooded.

Feral cattle used tree cover mostly during afternoon which was significant ($P < 0.002$) while the hourly use of shrub and herb cover was not significant.

Wild boar

Wild boar did not show any variation in the use of tree cover. The maximum use of shrub layer was during summer, probably because the animal uses it as shelter against sun and is reluctant to come out during the day unless disturbed.

Table 5.9

Crown area (in m^2) of tree and shrub on the transect in different blocks

Block	Tree	Shrub
B	513	878
C	473	708.5
F	141	168
G	256	204
I	430	1011
J	741	279
K	384	247
L(s)	253	112
M	753	1288
N	206	784
O	1782	1282

Table 5.10

Average crown area (in m^2) of tree and shrub on a plot of 200 m^2 in different habitat

Habitat	Tree	Shrub
WOOD	40.75	20.12
SCW	66.78	24.1
DST	22.5	15.56
SSH	6.3	22.3
SWS	13.48	12.67
GRS	6.62	0.68
LGR	16.68	7.39
SHS	4.5	12.66
MOS	4.66	3.83
WET	4.5	2.03

The use of different layers in different hours of the day did not vary much as the use of all the layers was uniform throughout the day (Fig 5.9).

5.3.3 Correlation between the rank in the preference of different habitat and tree and shrub crown area

Crown area

Crown area measured for tree and shrub along the transect shows that the total crown area of tree and shrub on either side of the transect sampled was 5932 sq.m. and 6961.5 sq. m. respectively. The maximum crown area of tree available was 1782 sq. m. in block 'O' while for shrub it was 1288 sq. m. in block 'M'. The minimum crown area of tree was 141 sq. m. in block 'F' while of shrub it was 112 sq. m. block L(s). The detail is given in table 5.9.

Crown area when sampled along the intersection of the grid of 400 m x 400 m in different habitat shows that the maximum crown area of tree was in scrub woodland (66.78 sq. m./ plot) followed by woodland (40.75 sq. m.) while in the case of shrub the maximum was also in scrub woodland (24.1 sq.m.) followed by scattered shrub (22.3 sq. m.). The crown area of shrub available was lower than that of tree in all the habitats except in scattered shrub (SSH) and shrub savannah (SHS) were the shrub crown area exceeds the tree crown area. The reason is obvious that in both the habitats the shrubs are dominant than the tree as indicated by the name of habitats. The details are presented in the table 5.10.

Ranking of different habitats in the park had been done on the basis of ungulates' preference for each (described earlier). Now the ranks of habitat have been correlated with the crown area (trees and shrubs) using Pearson- correlation coefficient.

No significant correlation can be made out between the crown *area of tree and rank of habitat preference except in the case of* Chital ($P < 0.05$) (Table 5.11). the plausible explanation of significance of this correlation is described earlier also is that Chital prefers to stay under the cover of trees during extreme weather in summer and winter.

Insignificant correlation has been worked out in respect of crown area of shrubs for all the species of ungulates except Chital and Nilgai . This phenomenon can be attributed to the fact that both these species partly feed on shrubs: Nilgai being a browser as well as a grazer throughout the year while Chital turns to partial browsing only during summer when grasses are scarce.

5.3.4 Niche breadth

While there was variation in the breadth of vegetation community use through season, generally the ungulate species of Keoladeo National Park appeared to expand their breadth during monsoon and winter and contract in summer.

The availability of food resources remain restricted to only certain parts of the park in summer, ungulates also congregate in those parts only. The situation changes in monsoon when food

Table 5.11

Correlation between rank of habitat prefernce and crown area of tree and shrub covered for different ungulates

	r (tree)	r (shrub)
Chital	0.667*	0.983 ***
Sambar	0.400	0.400
Blackbuck	0.500	0.500
Nilgai	0.317	0.800 **
Feral cattle	0.367	0.583
Wild boar	0.800	0.600

* Significant at level P = 0.05
** Significant at level P = 0.01
*** Significant at level P = 0.001

Table 5.12

Niche breadth of various species of ungulates based on habitat use

	Monsoon	Winter	Summer
Chital	0.322	0.384	0.1849
Sambar	0.087	*	0.0386
Blackbuck	0.035	0.0117	0.01625
Nilgai	0.6365	0.6127	0.37480
Feral cattle	0.1462	0.089	0.3429
Wild boar	0.2068	0.1316	0.1186

* Seen in only one habitat

resources become available in abundance almost throughout the park and ungulates also spread out and are seen occupying wider areas.

Chital

The niche breadth of Chital varied from 0.1849 in summer to 0.384 in winter (Table 5.12). The narrow breadth in the former season was due to the preference of some specific habitat (Scrub woodland and dense to discontinuous thicket) during this season where the availability of browse species is more. During this season Chitals are mostly dependent on browsing.

Sambar

The niche breadth of sambar varied from 0.0386 in summer to 0.087 in monsoon. During winter the Sambar were seen only in the aquatic area. The result shows that they are very specific in preference of habitat.

Blackbuck

Like Sambar, Blackbuck were are also specific in the habitat preference. During all the three season the niche breadth was narrow. It varied from 0.011 in winter to 0.03 in monsoon (Table 5.12). They mostly prefer low grassland area.

Nilgai

The niche breadth of Nilgai varied from 0.374 in summer to 0.636 in monsoon. The narrow breadth in the former season was due to the preference for scrub woodland and dense to discontinuous thickets where tree and shrub species are sufficiently available providing both cover as well as food. But in other seasons animals were seen uniformly distributed in almost all the habitats.

Feral cattle

The niche breadth of Feral cattle varied from 0.089 in winter to 0.3429 in the summer. The narrow value during the winter was due to the preference of only low grassland habitat though animals were seen in other habit but less in number. While during summer the value were wider than other season because during this season Feral cattle were seen in dried up wetlands area, savannah woodland to scattered tree and shrub besides low grassland.

Wild boar

The niche breadth of Wild boar varied from 0.11 in summer to 0.20 in monsoon. The values in all the seasons are narrower because Wild boar mainly preferred SCW and DST.

5.3.5 Similarity in the habitat utilization of various ungulates

So far, the differences in habitat utilization by different ungulate species have been described and highlighted. But some similarities have been observed and these have been described below.

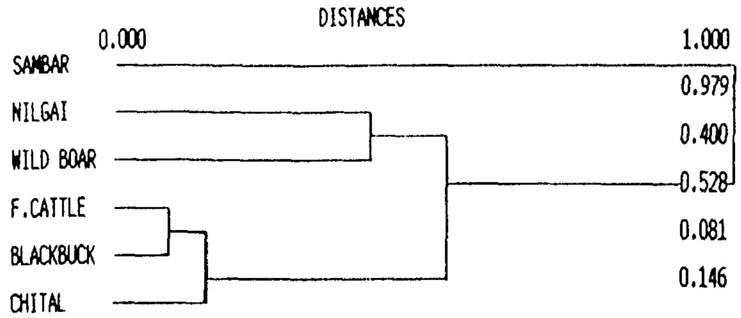
FIG 5.11

SIMILARITY IN THE HABITAT UTILIZATION OF UNGULATES

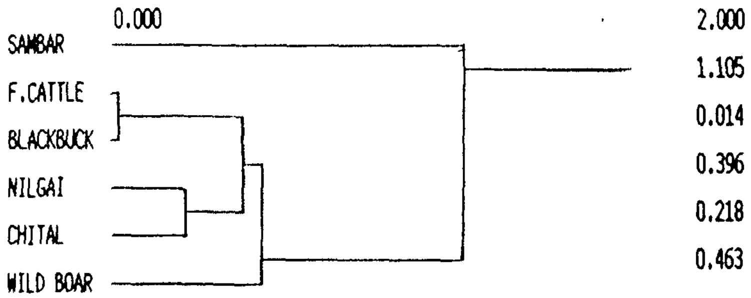
Distance metric is 1-Pearson Correlation Coefficient

Single Linkage Method (Nearest Neighbour)

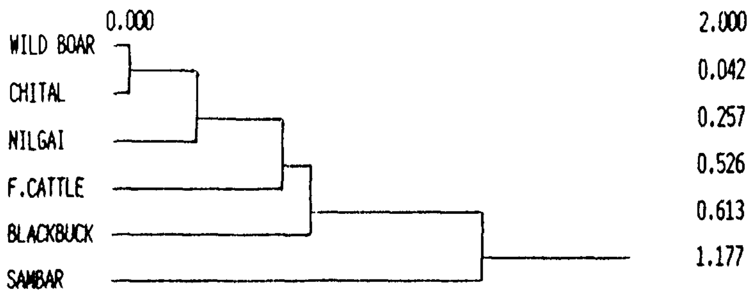
TREE DIAGRAM



MONSOON



WINTER



SUMMER

Similarity in the habitat utilization by ungulates at Keoladeo National Park was worked for different seasons.

Similarity during monsoon

Similarity in the habitat utilization during monsoon was seen between Blackbuck and Feral cattle. Chital was also closely associated with Feral cattle and Blackbuck but the association with the former was significantly higher ($P < 0.01$) than with the latter ($P < 0.05$). Although Nilgai occupied the same guild with Wild boar the correlation was not significant. Sambar formed a totally distinct guild in habitat utilization showing no similarity with other ungulates (Fig 5.11).

Similarity during winter

Four separate guild were distinguished during winter. Feral cattle and Blackbuck formed a single guild while Nilgai and Chital formed a different guild. Whereas, Wild boar and Sambar each formed a separate guild (Fig 5.11).

Similarity during summer

The similarity between habitat utilization by Chital and Wild boar was significantly ($P < 0.001$) higher (Fig 5.11). During summer most of the Chital moved towards the scrub woodland and dense to discontinuous thicket in search of forage. The availability of shrub, the main browse of Chital was abundant in this area. This area as mentioned earlier was the favoured habitat for Wild boar and hence both these species were found together.

The similarity in habitat utilization by Nilgai with other ungulates is corroborated in Fig 5.11. As in other seasons, Sambar formed a distinct guild in the habitat utilization showing no similarity with other ungulates. Chital and Wild boar too did not showed any similarity with Feral cattle and Blackbuck.

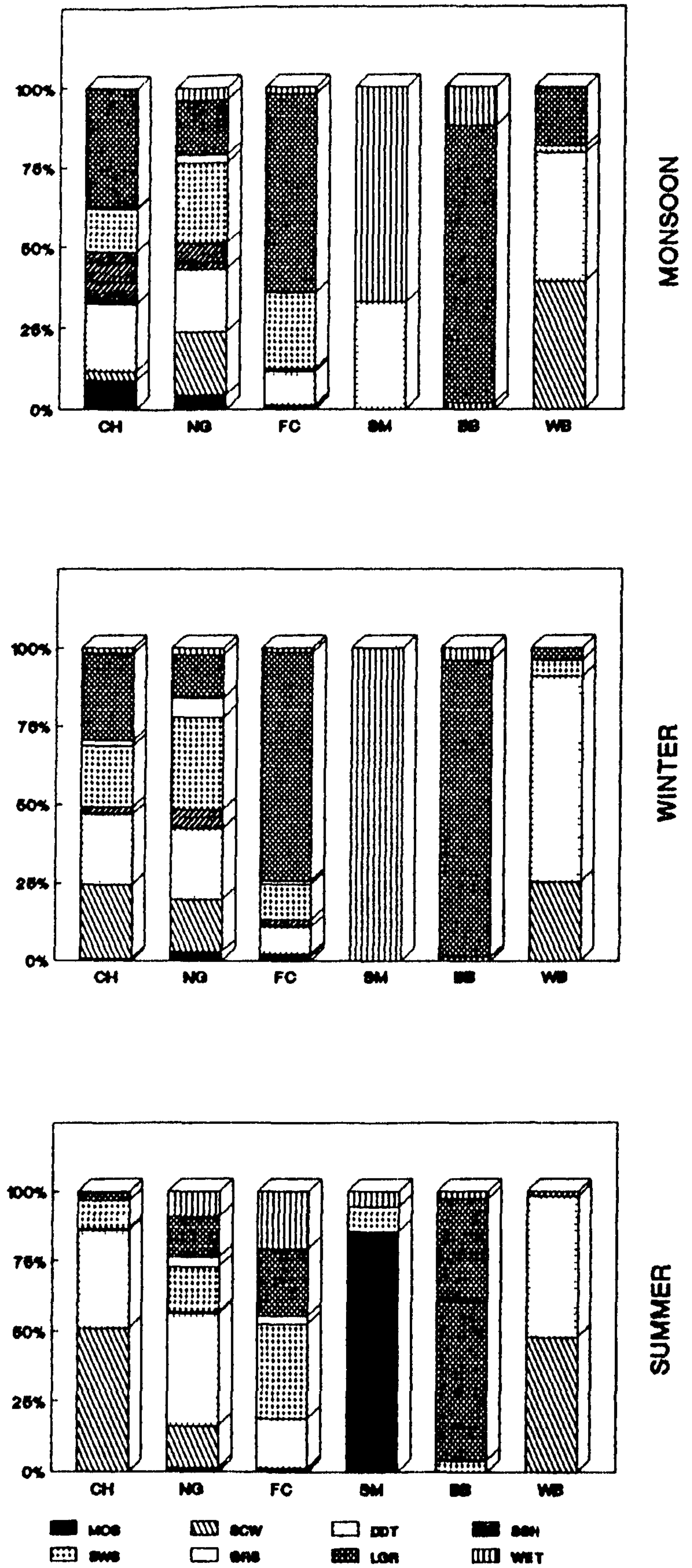
5.4 Discussion

The vegetation provides food, water, shade and cover. Of these the first is the most important. These features of vegetation vary in time and space, and the importance of each factor varies for different species, and even between individuals of one species. Jarman and Sinclair (1979) found that physical attributes of vegetation affect the habitat use of Impala in Serengeti. Clutton *et al.* (1982) reported the pronounced annual, seasonal and individual difference in the use of different plant communities by Red Deer *Cervus elaphus*. Similar phenomena were observed on the ungulates of Keoladeo National Park. The habitats of Keoladeo National Park were described earlier in detail by Haque (1988). I have also reported the general habitat use. In the present study the major habitats were further subdivided into micro habitats.

Feral cattle, Blackbuck and Chital utilized mainly the low grassland area during monsoon and thus similarity was distinct between each other during this season. This is attributed to the seasonal growth of herbs in the low grassland. Feral cattle and Blackbuck are grazers throughout the year while Chital is a grazer except in summer when it also browses. Berwick (1974) also found that Chital in the dry tropical Gir forest is primarily a

FIG 5.12

HABITAT PREFERENCE OF UNGULATES



CH = Chital NG = Nilgai FC = Feral cattle
WB = Wild boar SM = Sambar BB = Blackbuck

browser during the dry season. On the other hand, Schaller (1967) reported that in the moist semi-evergreen tropical habitat of Kanha, Chital mostly utilizes meadows, grazing on short grasses.

During winter Chital shared the habitat with Nilgai. This may be due to the preference of woodland habitat by the males of both the species (Haque 1988). During summer Chital were mainly seen in the scrub woodland and dense to discontinuous thickets (Fig 5.12) because of the abundance of browse species on which they mainly feed as the grasses had dried in the grasslands. The tree and shrub cover used by Chital during summer was comparatively higher than that in other seasons. This may be due to the structure of the vegetation of these habitats providing important thermal and hiding cover for the animal. This is also reported by Loft *et al.* (1987) for Mule deer. An overstory canopy assists deer in minimizing energy expenditure for thermoregulation by creating a microclimate that buffers extreme weather condition (Leckenby 1977, Peek *et al.* 1982). Understory vegetation in Keoladeo National Park provides relief from the weather for ungulate species that inhabit ares with dense shrub but is more important in providing hiding cover to escape from the stray dogs. This is also reported by Taber (1961).

Blackbuck as reported by earlier authors (Daniel 1967, Schaller 1967, Nair 1977) prefers grassland habitat the most in Keoladeo National Park. Brander (1923) found Blackbuck on open grass maidan surrounded by forest in Kanha N.P. Prasad and Rao (1984) studied the habitat preference of Blackbuck in Andhra Pradesh and found that it mainly prefers the open plain grasslands. According to Prater (1965) and Brander (1923), Blackbuck enters open forest which contain wide expanses of grass while Robert (1977) reported that Blackbuck avoids forest areas but survive in semi desert region as long as there is sufficient scattered vegetation. In Keoladeo National Park also, Blackbuck avoided the forest and if at all they were seen in the forest it was in the open patches. Blackbuck was seldom seen using tree or shrub cover at any time of the year.

Some information is available on the habitat preference of Nilgai through the work of Brander (1923) and Prater (1965). Both of them have described that Nilgai likes more or less open grassy hill forests sparsely covered with grass.

There appears significant similarity in habitat utilization by Nilgai and Wild boar. This similarity has been worked out on the whole year's basis of Nilgais' presence in the Wild boars' habitat. The average has risen to a significant level due to higher concentration of Nilgais' in wild boars' habitat during late monsoon and winter season when there is significantly higher availability of food resources there. Fresh growth of shrubs in that habitat is far more than in other parts of the Park and this also happens to be the rutting season of Nilgai. The distribution of Nilgai during rest of the year is more or less same throughout the Park.

The Nilgai in Keoladeo National Park shows a preference of habitat more or less similar to the one described by Berwick and Jorden (1971) and Berwick (1974) in the Gir forest. According to them Nilgai exist equally well in the most dense and in the most open habitats. The reason for their preference of savannah woodland to scattered tree and shrub (SWS) during summer seems to be the non-availability of grasses elsewhere during this period. During winter a few Nilgai were observed moving out of the Park through the openings in the boundary wall (Plate 7 and 8), and graz~~ed~~ing on the *Triticum aestivum* (wheat) and *Cicer arietinum* (chana) crops in the villages around the Park. Brander (1923) and Robert (1977) also have reported Nilgai raiding agricultural crops. A few Nilgai were seen in the wetland during winter (Fig 5.12), feeding on the aquatic macrophytes and leaves of *Acacia nilotica* (Plate 6) which has not been reported so far.

Apart from some studies by Brander (1923), Prater (1965) and Robert (1977) little is known about the habitat preference of Wild boar. According to Prater (1965) Wild boar inhabits forested habitats and not in open habitats of grassland. But Brander (1923) found that it exists both inside the forest and in the plains, while Robert (1977) reported that Wild boar need thick cover for shelter, particularly during the day time. A few studies have been done outside India on the habitat preference of Wild boar, which include the work of Baber and Coblentz (1977), Wood and Brenneman (1980) and Griggs (1981). Wood and Brenneman (1980) on the basis of his study on the feral hogs reported that hogs used swamp habitat intensively in all seasons. Studies on feral pigs show that they use different plant communities in response to the presence of a favourite food item. The present study in Keoladeo National Park indicates that the preferred habitat of Wild boar is scrub woodland and dense to discontinuous thicket which were mainly used for resting. They used to come out from thickets only during night or when disturbed. Very few Wild boar were seen in the aquatic area during monsoon and winter season probably due to the influx of tourists during this peak season as the species is secretive (Singer *et al.* 1984). Wood and Brenneman (1980) also found that pigs were disturbed in the marshes during summer and spring but the reason were not explained by them.

During the present study it was observed that Wild boar, while feeding at night on the tubers of *Scirpus tuberosus* and *Cyperus rotundus* uproot the sedges and grass in the marshy area adjacent to the woodland habitat mainly during early summer (Plate 10). Such a behaviour has also been reported by Wood and Brenneman (1980), Griggs (1981), Singer *et al.* (1984), Maryse (1986) and Baber and Coblentz (1987). Digging and uprooting of sedges and grasses by pigs threatens the plant communities (Bratton 1974). It may also permit invasion of exotic species (Spatz and Muller Dambois 1975, Jacobi 1976, Griggs 1981). Singer *et al.* (1984) in ~~his~~ study on the effects of wild pig uprooting in a deciduous forest found that there was negative impact~~s~~ on two litter dwelling vertebrates, ground vegetation cover, and concentrations of some nutrients in leaf litter and soil. In depth studies are called for to understand the ecological consequences of this behaviour of wild boar and to assess the role of the species in the concerned ecosystem.

Effects of wild pig disturbance have worldwide implication for agricultural lands during depredation on crops (Andrezejewski and Jezierski 1969, Mackin 1970, Robert 1977). Wild boar have been observed going outside the Keoladeo National Park, especially in summer, through the openings in the boundary wall and foraging in the adjacent crop fields. The damage caused to the crop has not been estimated. However, it has been reported that damage to the crop by Wild boar is a regular phenomenon throughout its distribution range (Chandran *et al.* 1977, Prasad *et al.* 1978, Green 1981, and Maryse 1986).

Sambar form a separate guild and it did not show any similarity with other ungulates in its utilization of habitat throughout the year. Sambar were seen in the aquatic area during most part of the year. Only during summer when the aquatic area dried up, the animals move towards the adjacent woodland areas. They remain there till the onset of monsoon and then moved back to the aquatic area.

No detailed study has been done on the ecological aspects of Feral cattle in the country. Gee (1958) reported that the Feral cattle of Bharatpur were quite similar to that in Britain. Dang (1959) gave some information on the distribution of feral cattle in Western Uttar Pradesh.

Gorden (1989) working on the ungulates of Rhum in which cattle was also one of the species, found that cattle mostly use the grassland and showed marked seasonal preferences for different vegetation communities.

Feral cattle at Bharatpur showed similarity with Blackbuck in habitat utilization. This similarity was found to be higher during monsoon and winter when the grasses are abundant throughout the Park. But during summer, when the grasses are scarce, cattle did not show similarity with any other ungulates. Dunbar (1974) in his study on the wild ungulates in Ethiopia found that in a community if all the species are increasing then there is less chance of competition. Chances of competition arises only when a species declined rapidly and simultaneously another species is found to be increasing. The number of Feral cattle at Keoladeo National Park had increased while the numbers of other wild ungulates are found to be stable. From this we cannot infer that wild ungulates compete for resource with feral cattle because in the earlier years (before 1982) the number of cattle was much higher (around 5000) when the grazing was allowed inside the Park. But long-term impact on the vegetation and indirectly on other species is not yet clear and need further study.

Niche breadth

The measurement of niche metrics from field data is essential for developing the theory of competition and related problems (Mac Arthur 1972). In some instances only crude quantitative information is needed, or a single measure for the average niche width and overlap in the group of species studied may be sufficient (Pielou 1972). According to Fretwell (1972) a species should show narrowing of habitat in season of resource restriction. Niche quantification and the concept of niche pattern has been described by various authors (Shugart and Patten 1972, Hanski 1978 and Hurlbert 1978).

The niche breadth of most of the ungulates in Keoladeo National Park has been observed to be wider during the monsoon season except of Feral cattle whose niche breadth widens in summer. The niche breadth of all the ungulate species in Keoladeo

National Park was observed to narrow down during the summer. The wider breadth during the monsoon was directly attributed to the new growth of vegetation during that season, while narrowing of niche width in summer appeared due to the scarcity of food resources. Similar pattern was noticed by Gorden (1989) working on the ungulates of Rhum. He noticed that the ruminant species in Rhum appeared to expand the spectrum of vegetation community use in spring and autumn and contract it in winter and summer.

The conclusions drawn from the present study are more or less the same. The only exception is the case of Feral cattle in Keoladeo National Park. In the present study it was observed that feral cattle, unlike other ungulates, expand their niche breadth during summer. Apart from several other possible reasons for this behaviour which have not been investigated by me, some of the apparent factors are as follows:

1. Feral cattle in Keoladeo National Park are mainly grazers and feed on grasses growing in dry areas (i.e. out of the marshes) (Plate 9). They are therefore confined to areas outside the marshes during monsoon and winter season, where they get enough food.

2. Larger areas of marshes dry up during summer which is dominated by *Paspalum distichum*. The Feral cattle are attracted to these areas also while simultaneously grazing over other areas.

3. Other species of ungulates also get attracted to dried up marshes but they do not forage in other habitats simultaneously.

4. Feral cattle feed on *Vetiveria zizanioides* and *Desmostachya bipinnata* growing in grass savannah habitat during summer. No other species utilizes this habitat nor feeds on tall grasses in that habitat.

Gorden (1989) also reported from his study that as the abundance of live material on the short grassland communities decline, cattle left the short grassland and ~~moves~~ toward the tall grassland communities.

5.5 Summary

1) The present study shows that the six species of ungulates of Keoladeo National Park show differences in the use of habitat. The Chital and Nilgai mainly prefer low grassland, scrub woodland, dense to discontinuous thickets and savannah woodland to scattered tree savannah. The Feral cattle prefers low grassland and savannah woodland to scattered tree savannah. On the other hand Sambar, Blackbuck and Wild boar prefer wetland, grassland and dense to discontinuous thickets respectively.

2) Insignificant correlation has been seen between the crown area of tree and habitat preference by all ungulates species except Chital. No significant correlation could be made out between the crown area of shrub and habitat preference by all ungulate species, except Chital and Nilgai.

3) The use of tree and shrub cover by all the ungulates was maximum during afternoon hours. The use of herbs' layer was maximum during early mornings and late evenings.

4) The niche breadth of most of the ungulates in Keoladeo National Park has been observed to widen during the monsoon season except of Feral cattle whose niche breadth widens in summer. The niche breadth of all the ungulate species (except Feral cattle) in Keoladeo National Park was observed to narrow down during summer.

5) Similarity in the habitat utilization between Feral cattle and Blackbuck was noticed during monsoon and winter seasons. Chital was found to be closely associated with Feral cattle and Blackbuck in both the seasons while Nilgai was closer to these species only during winter. Wild boar showed similarity only with Chital during summer. Sambar forms a totally distinct guild in the habitat utilization.

6. TIME BUDGET AND ACTIVITY PATTERN

6.1 Introduction

Time spent on various activities of ungulates in general is under the influence of environmental factors, particularly temperature and food. Unless there are other ecological reasons, animals tend to be active when the difference between their body temperature and atmospheric temperature is minimum. It may therefore be expected that ungulates (and for that matter all warm-blooded animals) will be in the open during the warmer part of the day in winter and during the tolerable part of the day (early in the morning and late in the evening or throughout the night) during summer, to escape the heat.

However, there may be other over-riding factors such as human disturbance, which may force the animals to modify their schedule. Distribution and availability of food which usually varies in different seasons also has a profound influence on the activity schedule. The animal has to spend much less time in feeding when food is abundantly and conveniently available while it has to spend much more time on feeding when food is scarce and is inconveniently available because it has to spend considerable time on searching and reaching the food.

Interaction between all these intrinsic and extrinsic factors determines the animals' activity schedules.

Daily activity pattern of ungulates is influenced by environmental factors and vary between species, reflecting a compromise to a number of factors that act simultaneously on the animals (Leuthold 1977). The effective management of wild animal population depends on a thorough knowledge of how each species interacts with its environment. One of the most useful methods for describing this relationship is to quantify the activity pattern shown in different areas and season (Norton 1981).

The activity patterns of many of the larger African ungulates are well-known through the work of Clough and Hassam (1970), Jarman and Jarman (1973), Mitchell (1977), Leuthold and Leuthold (1978), Irby (1981) and Sahar and Fairall (1987). Considerable studies have also been done on the Indian ungulates (Schaller 1967, Ables 1974, Nair 1976, Mungall 1978, Gadgil 1980, Sheffield *et al.* 1983, Prasad 1985, Green 1985 and Chattopadhya and Bhattacharya 1986).

The activity patterns of all the wild ungulates of Keoladeo National Park, except Wild boar have been studied. The wild boar could not be studied because it does not permit regular and proper observation due to its secretive nature.

6.2 Methodology

The activity patterns were studied between July 1988 and June 1989. The method suggested by Altman (1974) were used for quantifying the daily activity of ungulates.

Data was collected by direct observation of free ranging animals through a pair of 8 x 30 binoculars. Individual activity was recorded for only daylight hours from dawn to dusk. During each observation period, the main activities of each individuals in a herd or group were observed and noted at 10 minutes' intervals. The time spent by individuals in each activity was recorded for five minutes each time in between the intervals, using focal sampling method. The data collected from the scanning method was used to know the activity pattern of the animal while that of focal sampling for the time budget. The activity (feeding and resting) pattern was worked out by comparing the two sets of data.

Activities were classified as feeding, resting, standing, and others (running, display, defecation etc.). Most of the continuous observations lasted for 10-12 hours, although on a few occasions continuous activity records were obtained only for 5-6 hours. While observing the behaviour an activity was considered only when the time spent in that activity exceeded 30 seconds before change over to the next activity. The average time spent by the animals in each hour of daylight was calculated separately for summer, winter, and monsoon and expressed in terms of percentage.

The correlation between total time spent in each activity and atmospheric temperature was determined using a Kendal correlation co-efficient. The seasonal differences for all the season combinations for each activity were calculated by Mann-Whitney 'U' test.

6.3 Results

6.3.1 Chital

Time budget

There were distinct peak hours for feeding during monsoon with a maximum of 56.6% between 6-7 hours and again 52 % between 17-18 hours. During the rest of the daylight hours feeding time ranged between 12% to 28%.

During winter feeding was infrequent in the early hours. However, it increased to 39% between 8 and 9 hours and 34% between 13 and 14 hours and, again a peak was discernible at ~~the~~ 17 hours (57%).

The feeding time during summer was found to reach its peak *only in the early morning from 6 to 7 hours and late evening from* 17 to 18 hours (Fig 6.1).

The correlation between feeding and temperature shows a negative relationship during all the three seasons. But it was significant only during summer ($P < 0.05$). Although Mann-Whitney test showed no significant differences between the feeding activity in different seasons, average values for feeding were maximum for monsoon (Table 6.1).

Resting activity was observed to touch the peak at different times of the day in different seasons. In the monsoon the peak was between 12 and 13 hours while in the winter it was between

FIG 6.1

TIME BUDGET OF CHITAL

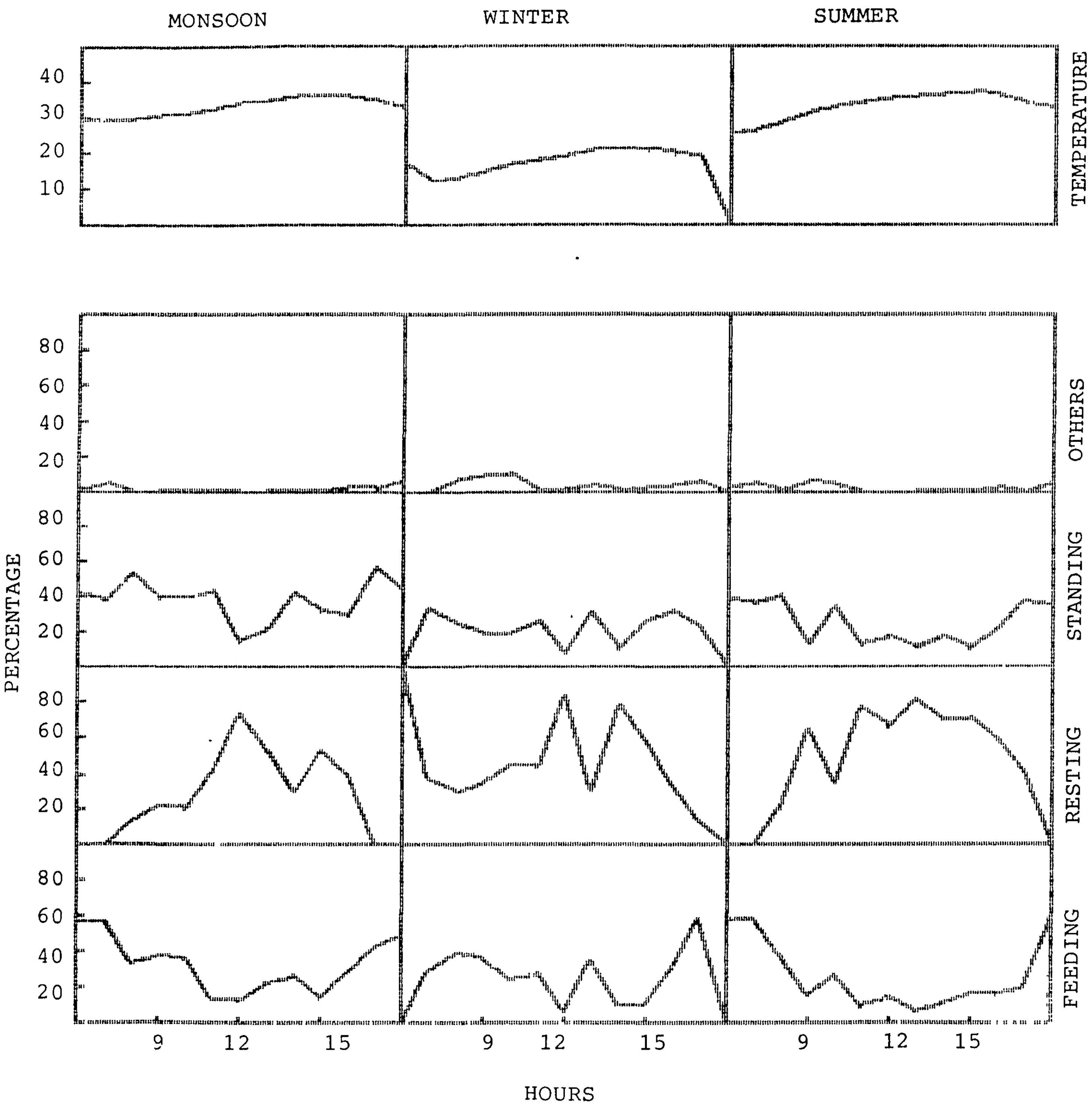
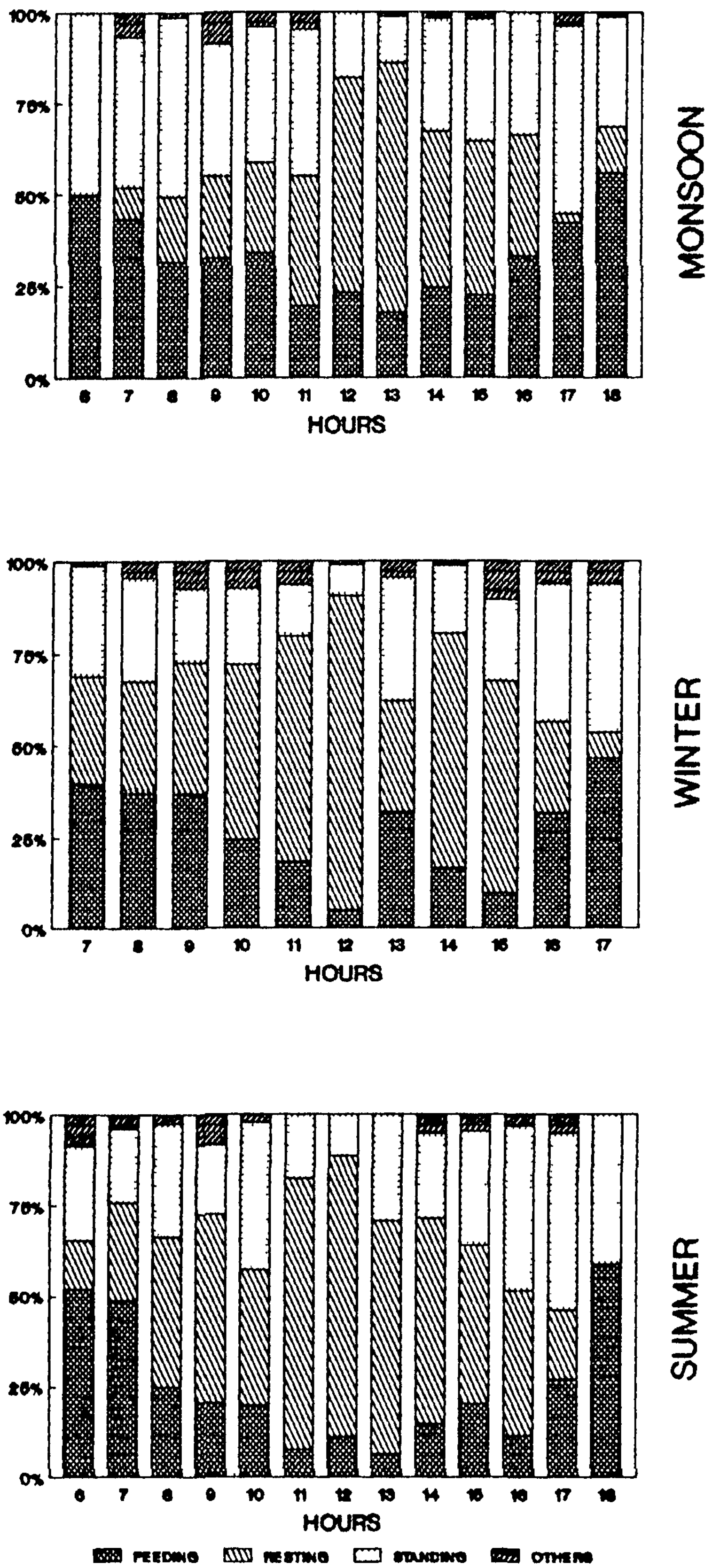


FIG 6.2

ACTIVITY PATTERN OF CHITAL



6 and 7 hours and then between 12 and 13 hours. During summer the animals were observed spending most of the time lying except early in the mornings and late in the evenings, with a peak time from 11 to 15 hours.

Resting showed a positive correlation with the atmospheric temperature. However, this correlation appears significant only during summer ($P < 0.01$). The time spent for resting differed between monsoon and summer ($P < 0.05$).

The standing activity was found to be maximum during monsoon season while other activities classified as `others' was maximum during monsoon. A negative correlation exists between time spent for standing and temperature during monsoon and summer, but it was significant only during the latter season ($P < 0.05$) (Table 6.2). The time spent for standing during monsoon differed with that of winter; maximum time was spent during winter.

Activity pattern

Feeding

Most of the Chital during monsoon (July-October) were found to be feeding in the day time except a brief spell around noon when less than 30% individuals were seen to be active. The feeding activity reached its peaks once in the morning from 6 to 8 hours and again in the evening from 16 to 18 hours (Fig 6.2).

FIG 6.3

THE FEEDING PATTERN OF CHITAL BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS

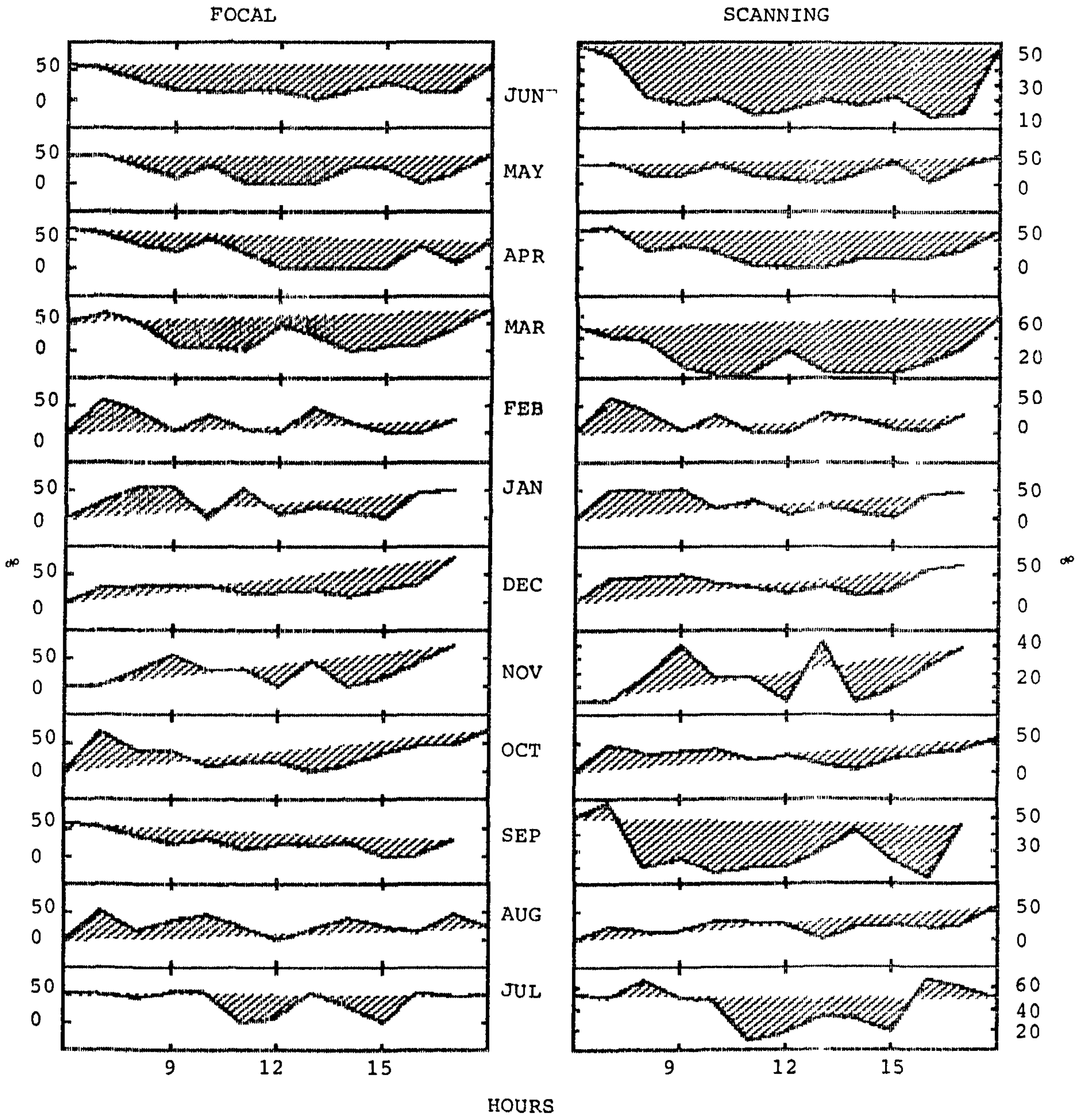
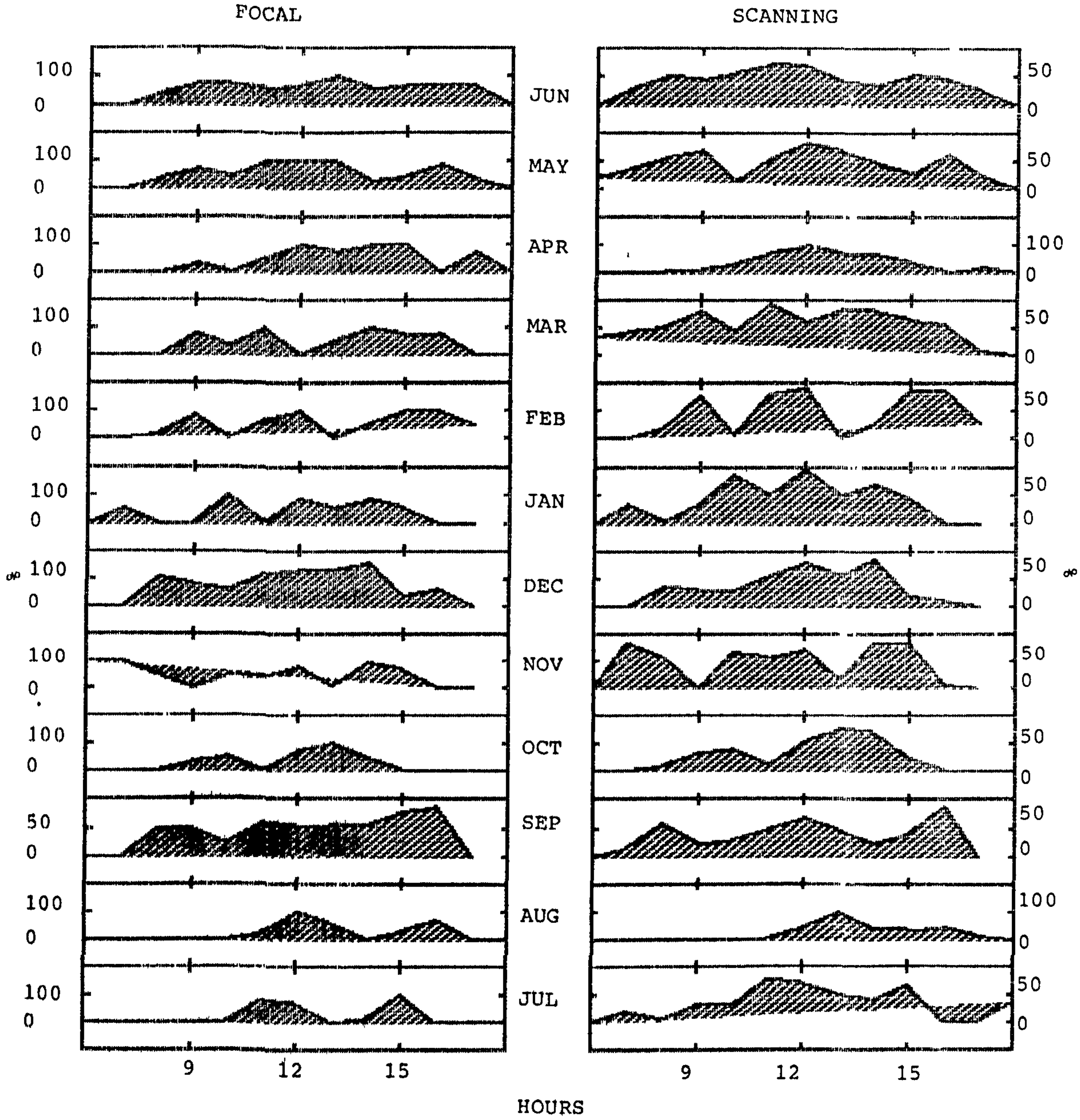


FIG 6.4

THE RESTING PATTERN OF CHITAL BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS



The more or less similar pattern was seen during winter. The only difference was that the peak of the activity was from 7 to 9 hours and again from 16 to 17 hours. This late peak in the morning and early peak in the evening in winter when compared to that during monsoon has been found to be directly related to the sunrise and sunset time.

The feeding activity in the summer was seen mostly from 6 to 7 hours and again from 18 to 19 hours. During noon less than 15% of the individuals were seen feeding during summer.

Resting

During monsoon Chital were seen mostly resting during the noon hours. After 8 hours the resting period gradually increased from 25% and it reached its peak (65%) at 12-13 hours and again it gradually declined towards the evening hours.

During winter at 6 hours most of the Chital were seen resting under the trees because of severe cold. Only after the temperature increased they come out for feeding. The resting period gradually increased from 9 hours and reached to its peak at around 12 noon and then gradually declined (Fig 6.2).

In the case of summer season only 30% Chital were seen resting in early hours of the day. The resting activity gradually increased from 8 hours when more than 50% Chital were seen resting and it reached its peak at 11-12 hours when around 80% animals were seen resting and then it gradually declined. Maximum time was observed spent on resting during summer season, at the cost of other activities.

Table 6.1

The average time spent in percentage by various ungulates for different activities during different seasons

		Feeding	Resting	Standing	Others
	Monsoon	33.04	26.51	38.40	1.85
Chital	Winter	25.51	49.12	21.36	4.10
	Summer	26.89	45.23	25.53	2.22
	Monsoon	31.74	47.59	19.10	1.55
Sambar	Winter	24.89	56.98	16.49	1.58
	Summer	22.62	66.15	8.58	2.75
	Monsoon	29.67	40.58	26.06	3.66
Blackbuck	Winter	29.34	45.78	21.95	2.88
	Summer	26.22	45.53	24.82	3.35
	Monsoon	34.49	30.85	32.45	2.20
Nilgai	Winter	30.48	44.29	22.60	2.62
	Summer	25.38	46.36	25.61	2.64
	Monsoon	35.4	29.83	32.62	2.4
Feral cattle	Winter	25.84	45.75	25.22	3.35
	Summer	33.50	40.61	22.72	3.14

Apart from the feeding and resting activity pattern, the animals were mostly found standing. Other activities, not separately classified, occupied negligible time.

The pattern obtained by focal and scanning methods, for feeding and resting activities of Chital, showed the similar trend for all the months (Fig 6.3 and 6.4).

6.3.2 Sambar

Time budget

The study on activity pattern and time budget of Sambar was carried out only for 10 months. Data for May and June was not collected because with the onset of monsoon the animals move to terrestrial area where thick growth of bushes does not permit proper observation. The data for summer were therefore averaged for only two months.

There were three distinct peaks for feeding during all the three seasons; between 6 and 8 hours, 12 and 14 hours and 17 and 18 hours. The average percentage was maximum during monsoon (32%) (Table 6.1).

Correlation between feeding and temperature was not significant, although it was negative during monsoon and winter (Table 6.2). There was no significant seasonal variation.

The average resting activity was maximum during summer (66%). During all the seasons the animals were seen lying on the

FIG 6.5

TIME BUDGET OF SAMBAR

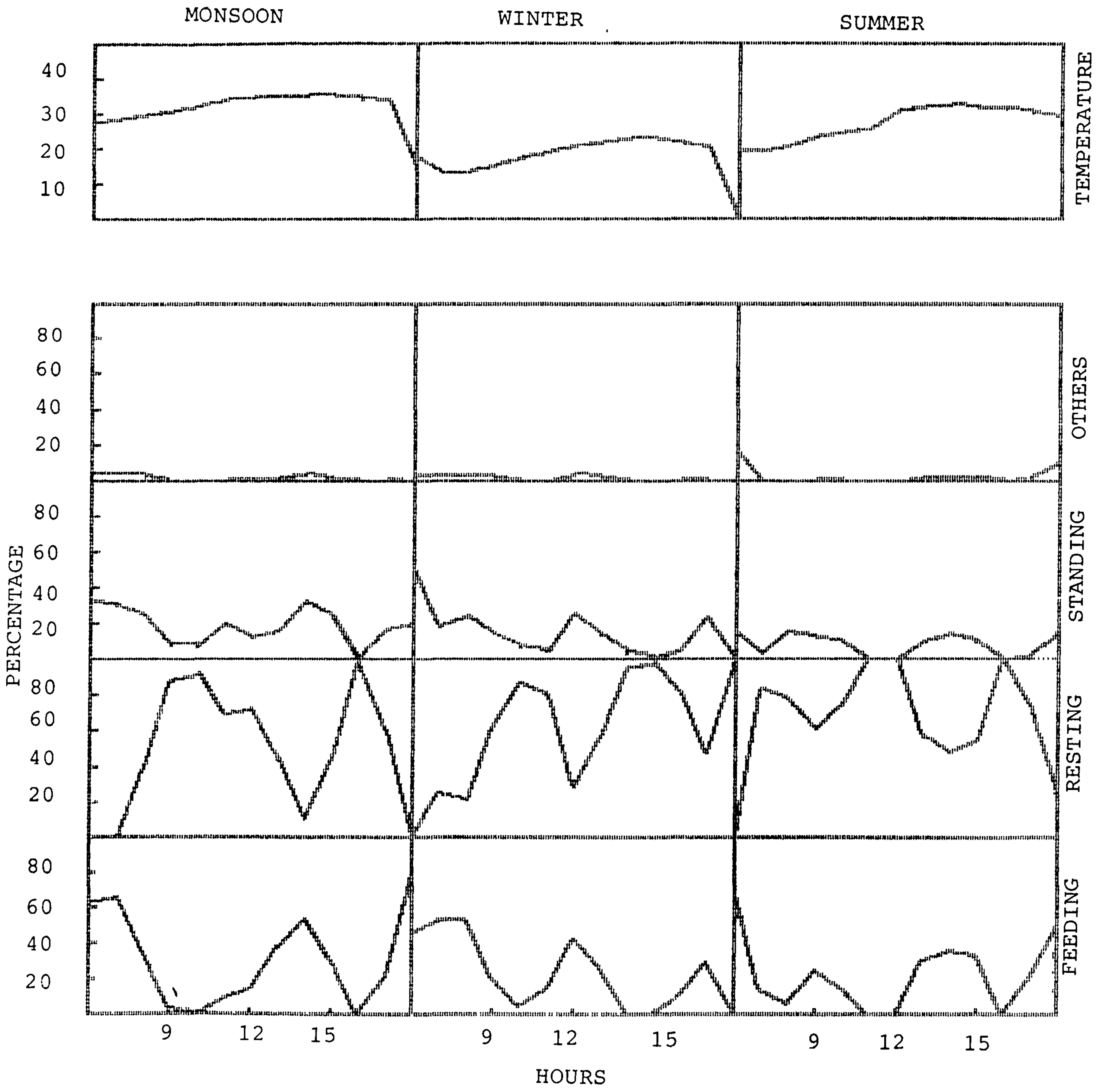
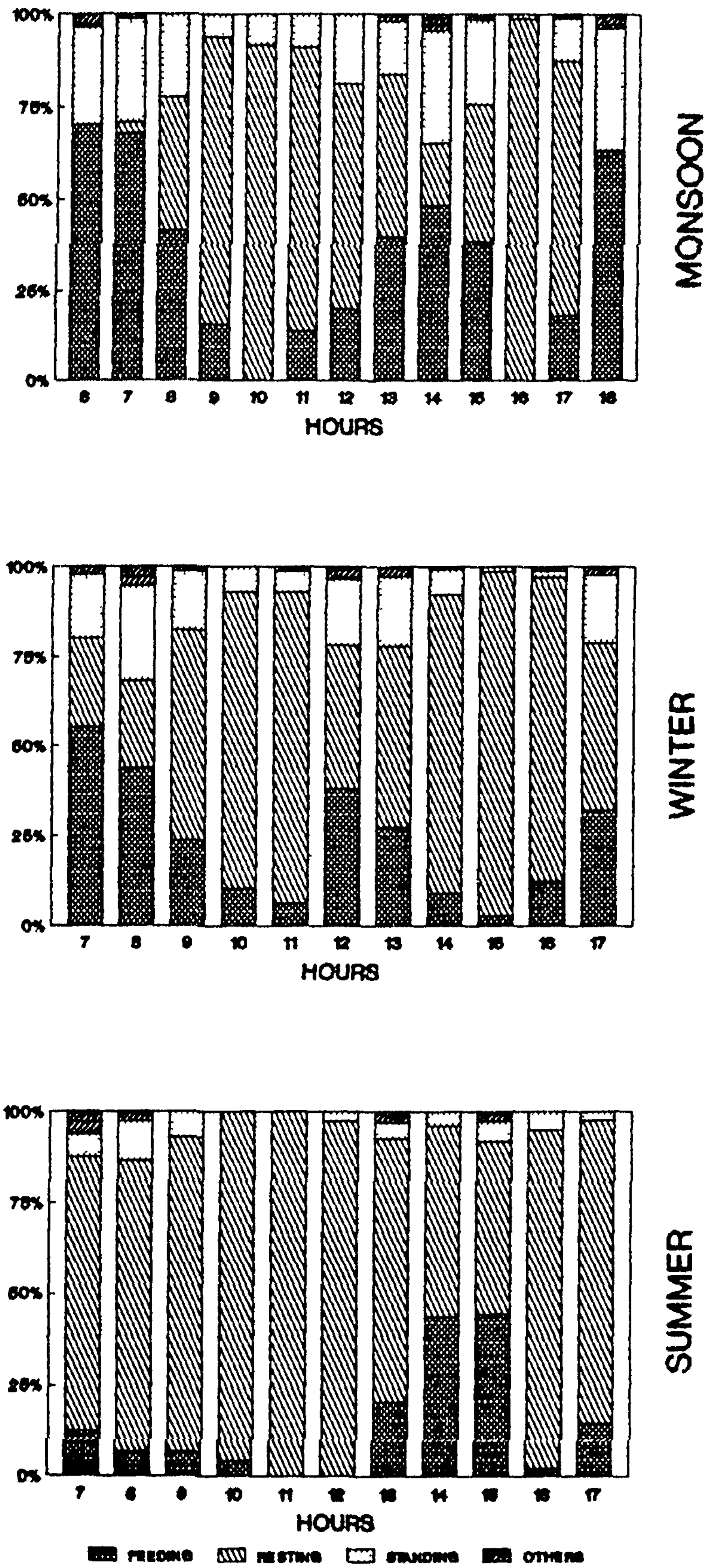


FIG 6.6

ACTIVITY PATTERN OF SAMBAR



mounds in the aquatic area. The peak resting activity was between 9 and 12 hours and again between 15 and 17 hours during monsoon and summer while there was a slight change in the peak during winter when it was between 9 and 11 and 13 and 16 hours (Fig 6.5).

Activity pattern

Feeding

During monsoon around 70% Sambar were seen feeding from 6 to 7 hours and 40% from 13 to 15 hours. The feeding activity appeared to slow down from 15 hours and start again after 18 hours. It continued till the observation period came to an end.

Feeding activity was observed to start later in the winter season, around 7 hours and its evening peak to reach about an hour earlier than in monsoon.

The summer schedule was found to be different from that of other seasons, partly because the observation period got prolonged with the day length and partly because of the presence of grass cutters who are allowed only in summer. Most of the animals were seen feeding during the early hours of the day and between 13 and 15 hours (Fig 6.6). Few animals were found feeding in the evening due to the disturbance ~~of~~ grass cutters.

Resting

During monsoon most of the Sambar were seen resting between 8 and 12 hours and between 15 and 17 hours. The resting

FIG 6.7

THE FEEDING PATTERN OF SAMBAR BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS

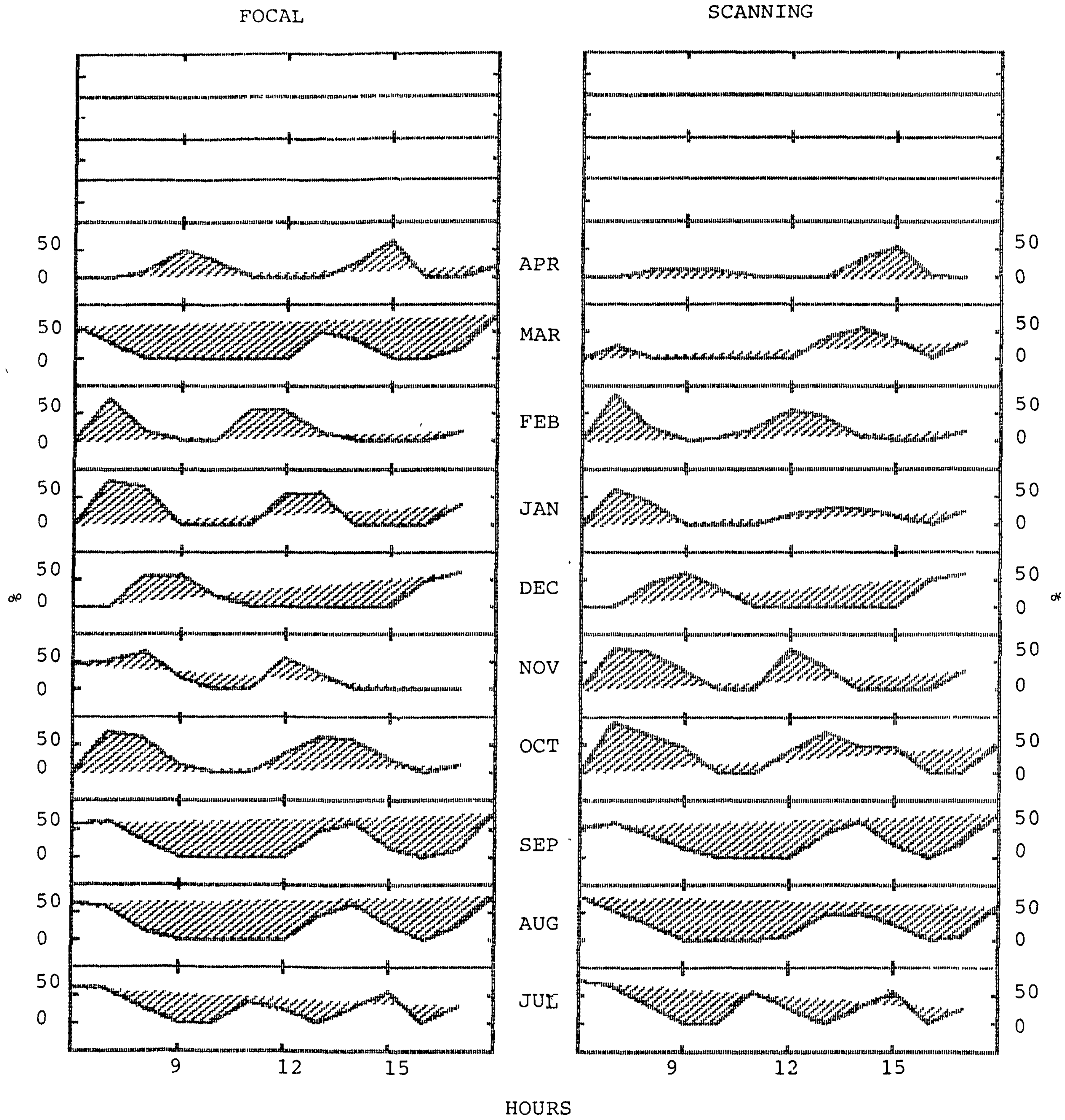
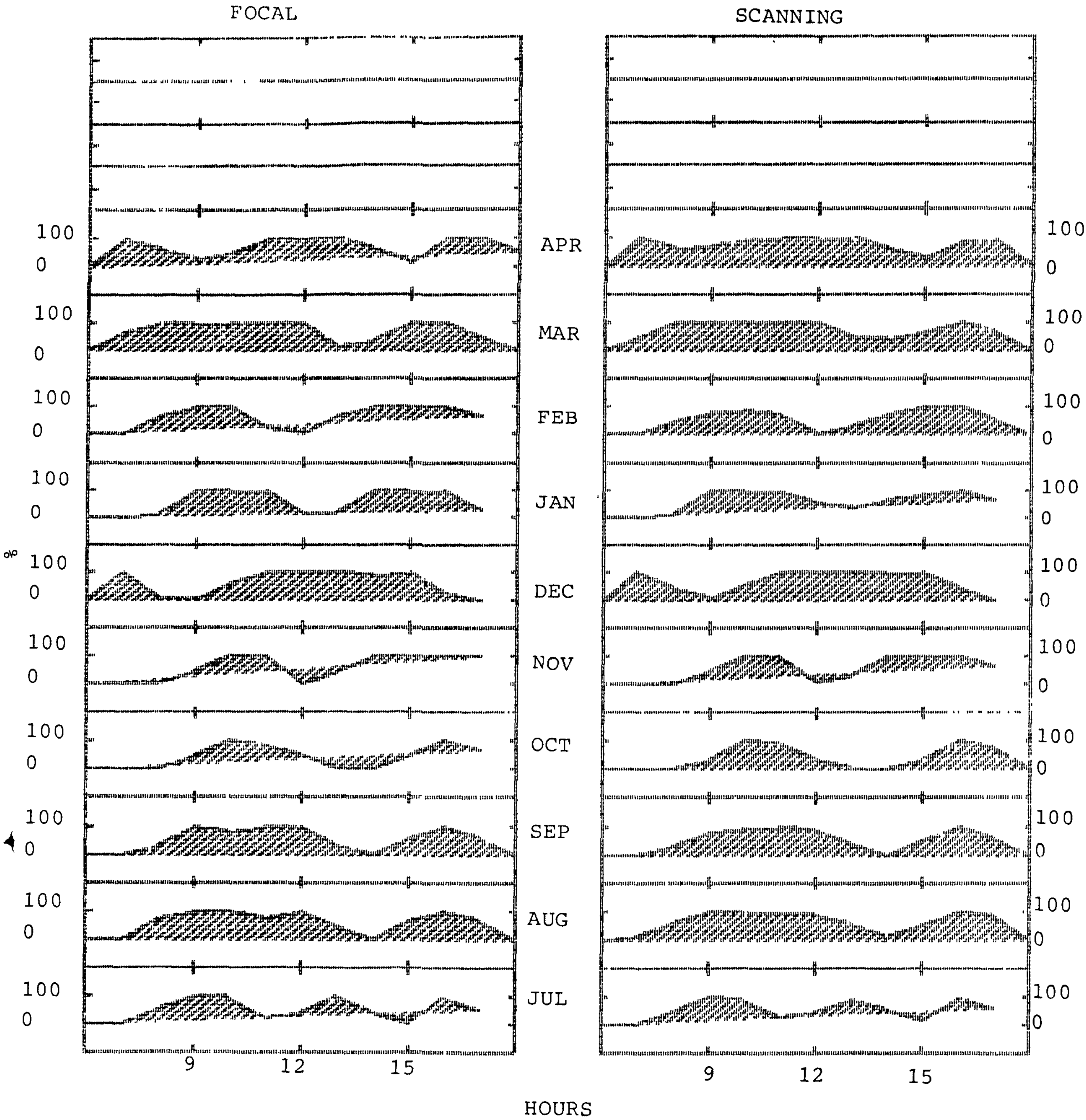


FIG 6.8

THE RESTING PATTERN OF SAMBAR BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS



activity gradually increased from 8 hours and reached its peak from 10 to 12 hours when more than 80% Sambar were seen resting. Then again from 12 hours it declined through 15 hours when less than 50% Sambar were seen resting. Again after 15 hours it gradually increased and reached to its peak at 16 hours when more than 90% Sambar were seen resting (Fig 6.6).

During winter season the pattern of resting activity was more or less similar like of monsoon. Whereas, the resting activity during summer was different from other season. Most of the Sambar during summer were seen resting throughout the days except in the early hour from 6 to 8 hours and in afternoon from 13 to 14 hours when less than 50% were seen resting. In the late evening most of them were seen resting.

Apart from the feeding and resting activity pattern, the animals were mostly found standing. Others activities, not separately classified occupied negligible time.

The pattern obtained by focal and scanning methods, for feeding and resting activities of Sambar, showed the similar trend throughout the years (Fig 6.7 and 6.8).

6.3.3 Blackbuck

Time budget

In all the three seasons there was a distinct peak of feeding activity between 6 and 7 hours and 17 and 18 hours. During monsoon the peak was noticed also between 12 and 13 hours.

FIG 6.9

TIME BUDGET OF BLACKBUCK

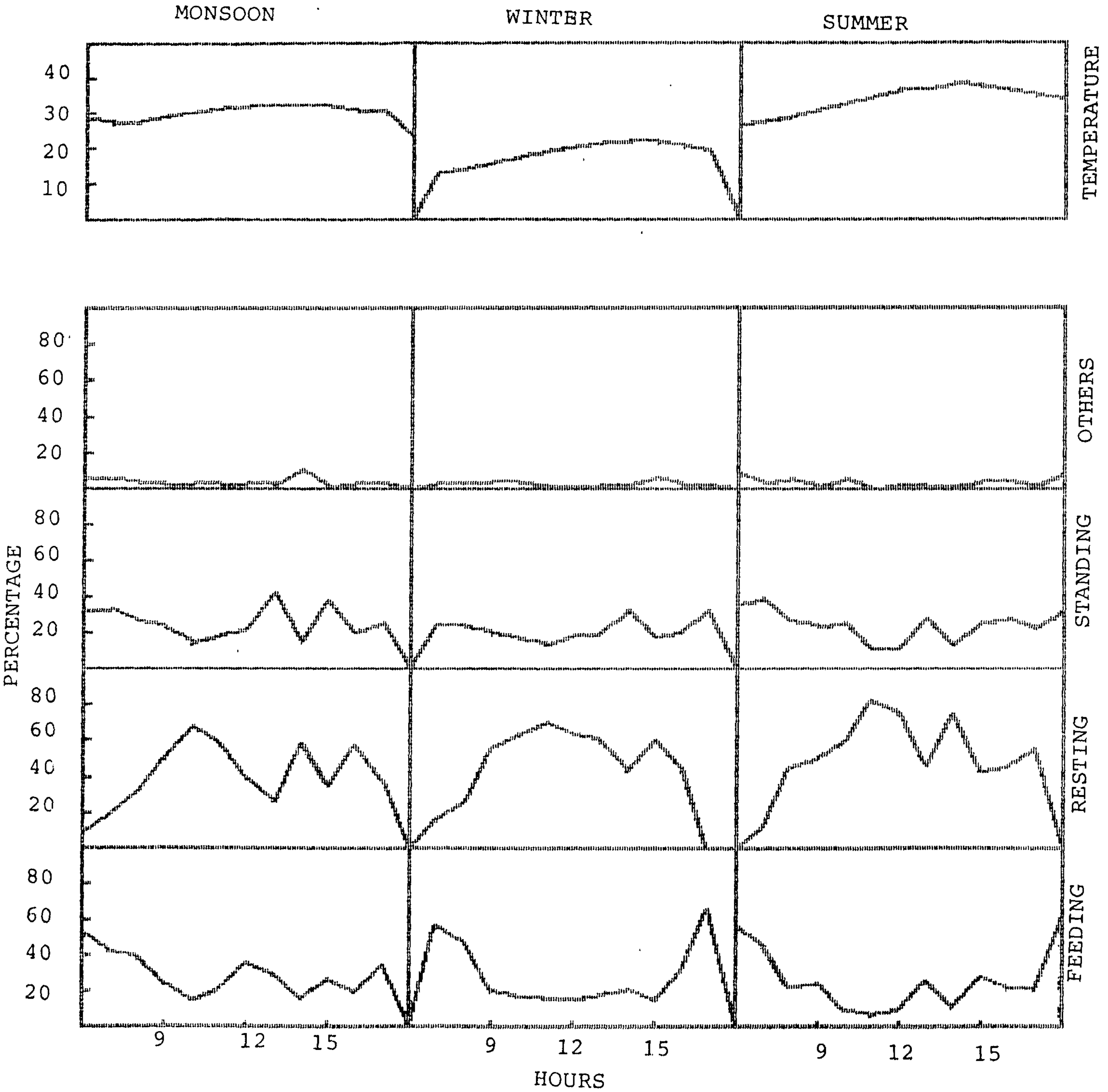
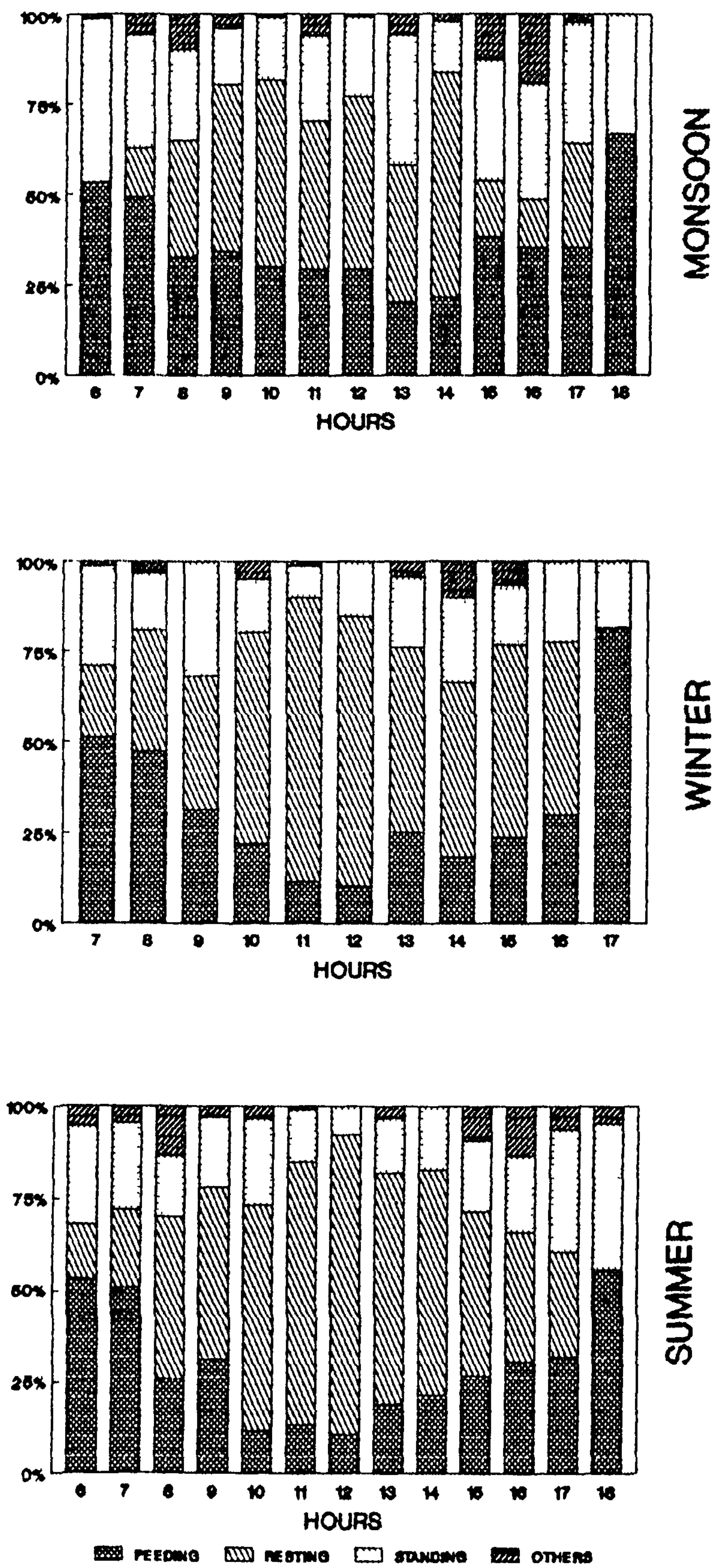


FIG 6.10

ACTIVITY PATTERN OF BLACKBUCK



The average percentage of time spent on feeding was equal during monsoon and winter seasons (Table 6.1). The correlation between the time spent for feeding and atmospheric temperature was not significant (Table 6.2).

Resting period was brief (19%) in the early hours during monsoon, and it increased to 58% between 9 and 11 hours and between 14 and 16 hours it was 49%. During winter the maximum resting was between 11 and 13 hours (64%) while during summer it was between 11 and 12 (75%) (Fig 6.9). There was no significant correlation between resting and temperature.

'Standing' reached the peak in the morning and evening hours in all the seasons. There was no significant correlation between atmospheric temperature and standing as well as other activities. No significant seasonal variation was observed in respect of other activities as well.

Activity pattern

Feeding

'Feeding', during monsoon season reached its peak thrice in a day; first from 6 to 7 hours with around 50% animals found busy in grazing. The activity picked up again and reached its peak around 11-12 hours when 30% to 40% animals were observed feeding. Finally, feeding touched the third peak from 17 to 18 hours with more than 65% animals were seen busy in grazing.

FIG 6.11

THE FEEDING PATTERN OF BLACKBUCK BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS

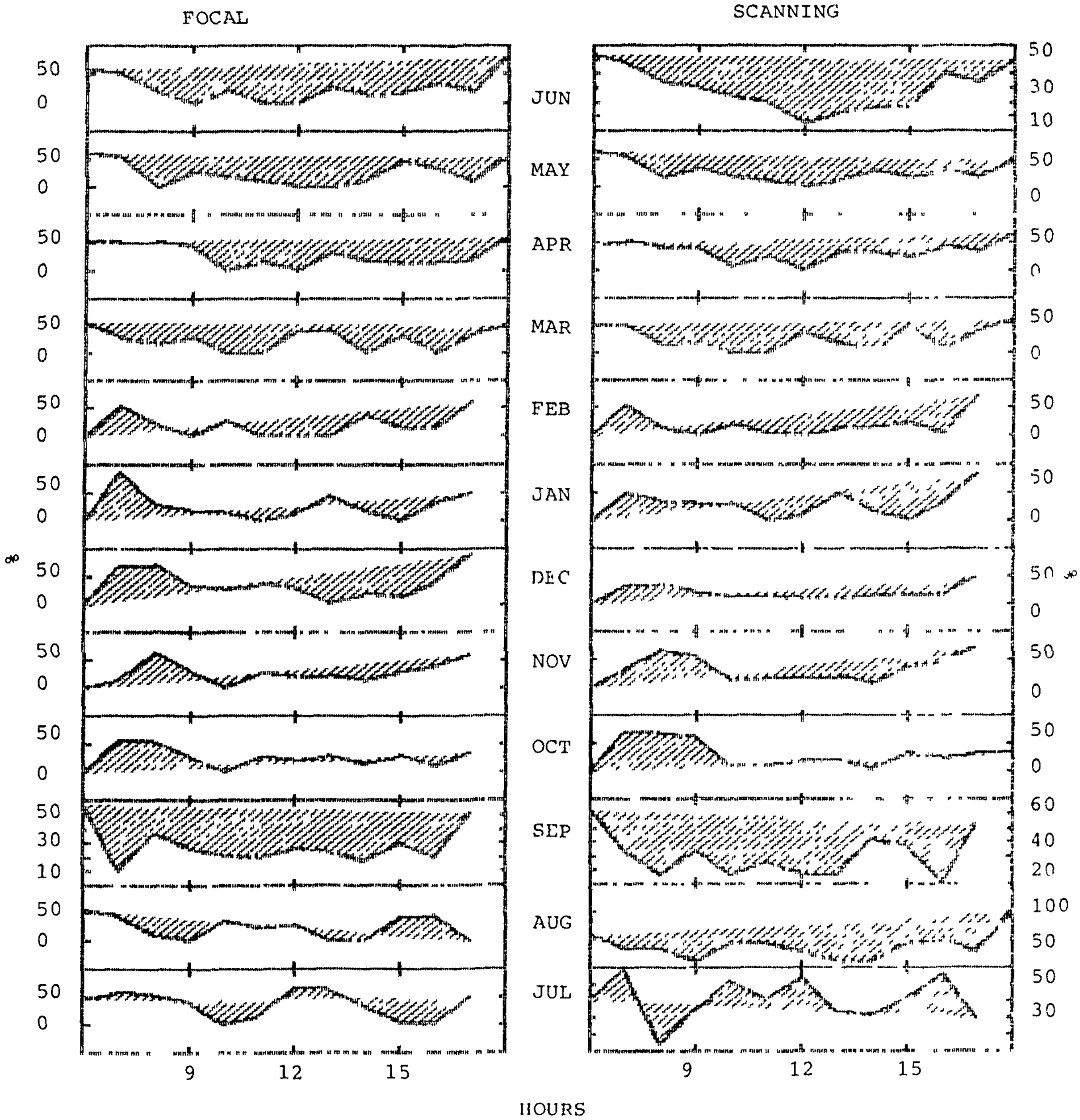
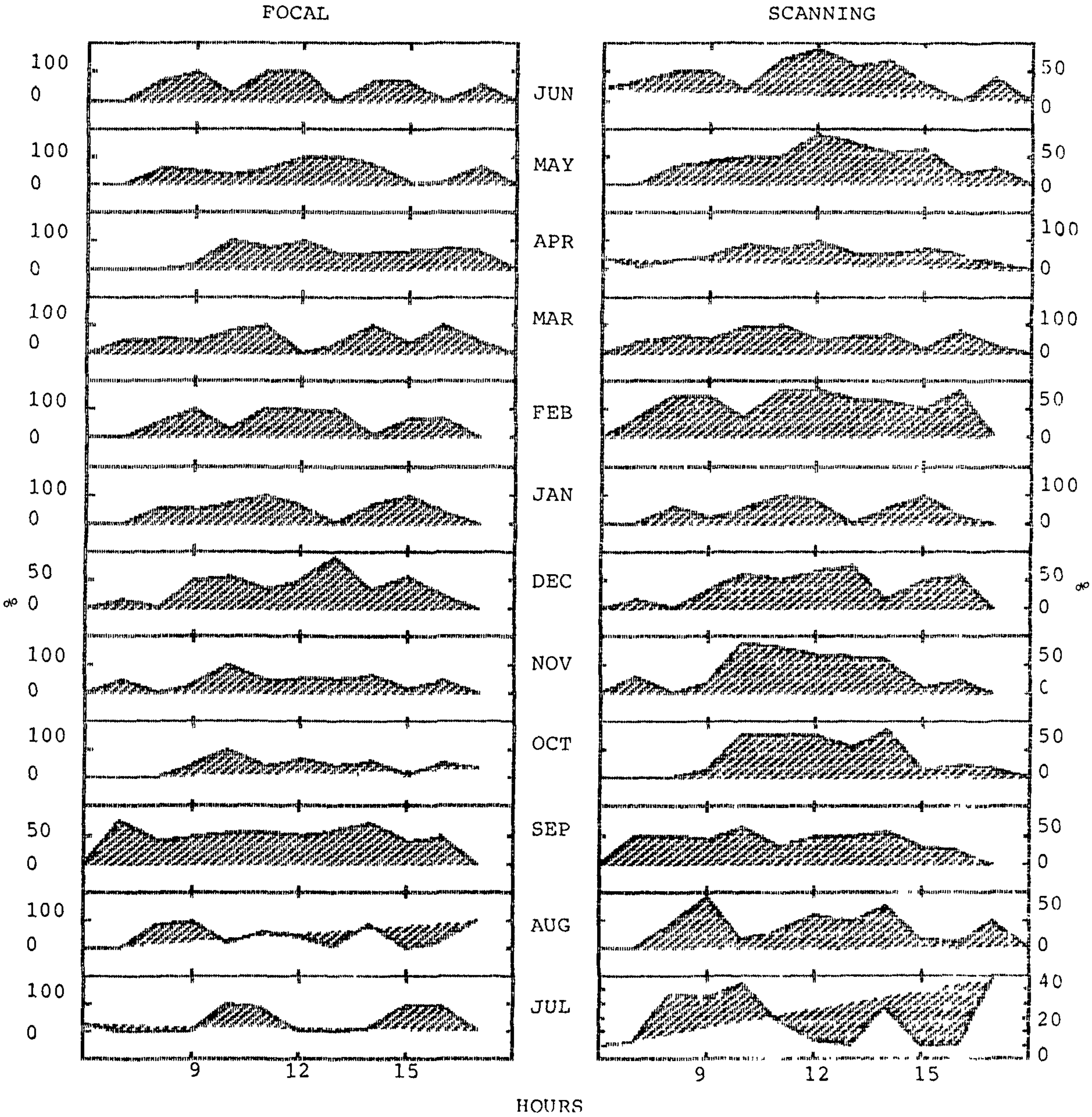


FIG 6.12

THE RESTING PATTERN OF BLACKBUCK BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS



During winter the peak was noticed in the early morning; 7-9 hours and again between 16 and 17 hours when more than 50% Blackbuck were seen feeding. No peak was noticed during the noon hours in winter season.

In summer more than 50% animals were seen grazing between 6 and 7 hours and then the number gradually decreased and the second peak was noticed again from 18 to 19 hours when more than 55% Blackbuck were seen feeding.

Resting

The resting activity during monsoon gradually increased from 8 to 9 hours when more than 40% Blackbuck were seen resting. It reaches to its peak from 12 to 14 hours when more than 60% animals were resting and then it gradually declined when less than 30% Blackbuck were seen resting (Fig 6.10).

During winter the resting activity gradually started from 9 hours when 50 to 60% Blackbuck were seen resting. It reached its peak from 11 to 14 hours when more than 75% Blackbuck were seen lying and then it gradually declines.

During summer the resting activity started increasing from 8 hours when 40-50% Blackbuck were seen resting. It reached its peak from 10 to 14 hours, when more than 75% animal were lying and then it gradually started declining when only 35-45% animals were seen involved in resting activity.

Table 6.2

The correlation coefficient (r) between the temperature and different activities of various ungulates during different seasons

		Feeding	Resting	Standing	Others
	Monsoon	-0.462	0.454	-0.154	0.104
Chital	Winter	-0.039	0.282	0.116	0.013
	Summer	-0.538*	0.667**	-0.590*	-0.327
	Monsoon	-0.142	0.196	-0.051	0.068
Sambar	Winter	-0.327	0.205	-0.179	-0.185
	Summer	0.039	-0.053	-0.211	0.086
	Monsoon	-0.128	0.410	-0.026	0.026
Blackbuck	Winter	0.039	0.408	0.247	0.078
	Summer	0.039	0.408	0.247	0.078
	Monsoon	-0.256	0.297	-0.282	0.312
Nilgai	Winter	0.039	0.194	0.348	0.207
	Summer	-0.436	0.426	-0.513 *	-0.137
	Monsoon	-0.385	0.588	-0.051	-0.065
Feral cattle	Winter	-0.065	0.196	-0.142	-0.107
	Summer	-0.385	0.410	-0.359	-0.092

* = Significant at level P = 0.05

** = Significant at level P = 0.01

The pattern obtained by both focal and scanning methods, for feeding and resting activities of Blackbuck, were similar for all the months (Fig 6.11 and 6.12).

6.3.4 Nilgai

Time budget

In monsoon the peak for the feeding was from 6 to 7 hours (52%) and again between 16 and 18 hours (61%). A similar pattern was observed also during summer. But in winter, considerable less time was spent in the feeding during early hours. The correlation co-efficient between feeding and atmospheric temperature was not significant (Table 6.2).

Resting showed a definite peak between 11 and 12 hours during monsoon (70%) and winter (65%) (Fig 6.13). However during winter a higher peak was also noticed in the early hours which may be due to the mist and low temperature. During summer except in early morning and late evening all the time animals were seen lying. The peak was noticed between 10-14 hours. There was no significant correlation between temperature and resting.

Standing and other activities showed the peak in morning and evening hours during monsoon and summer while during winter no peak was noticed in any daylight hours. A negative correlation exists between time spent for standing and atmospheric temperature was negatively correlated ($P < 0.05$).

FIG 6.13

TIME BUDGET OF NILGAI

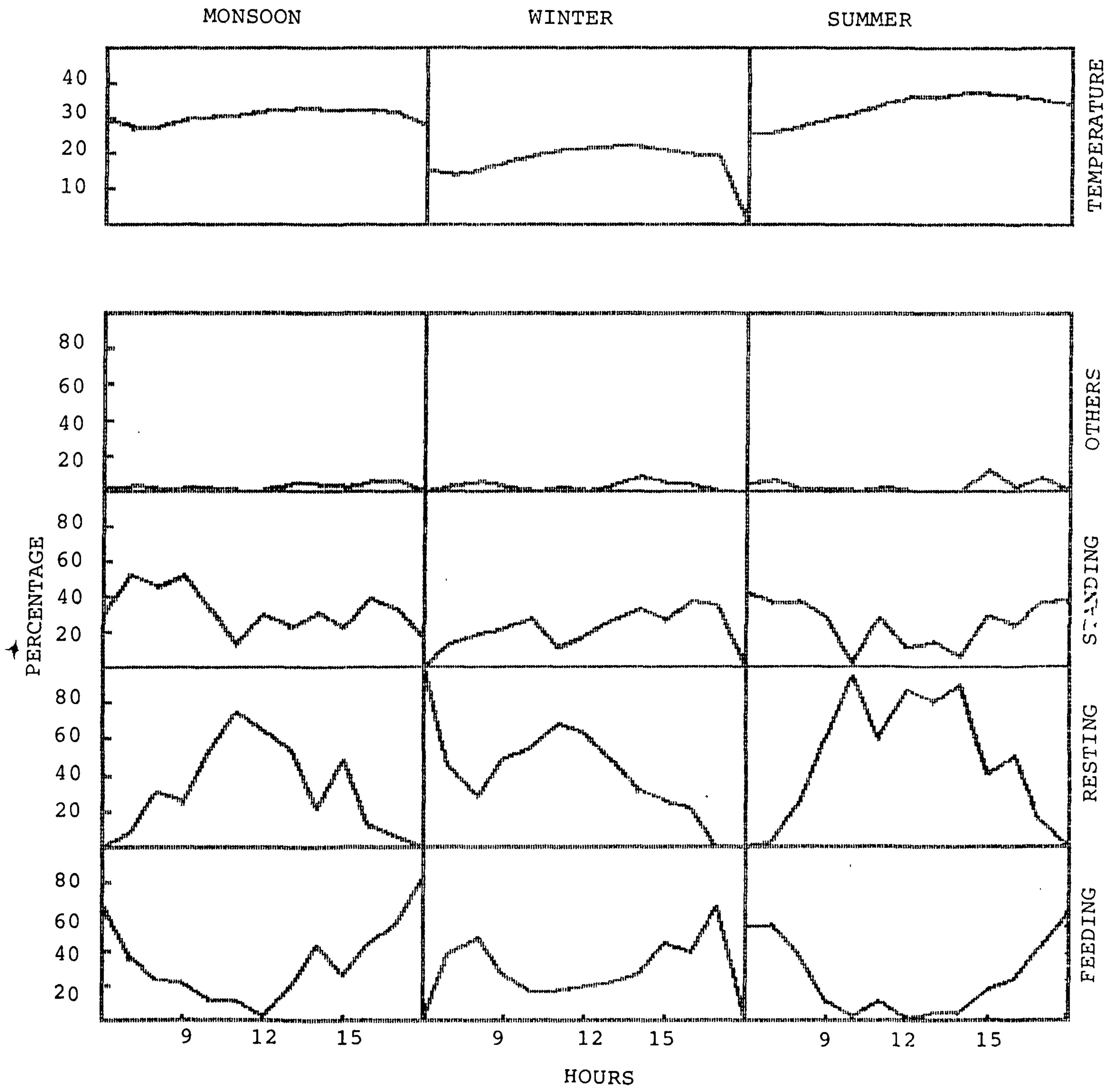
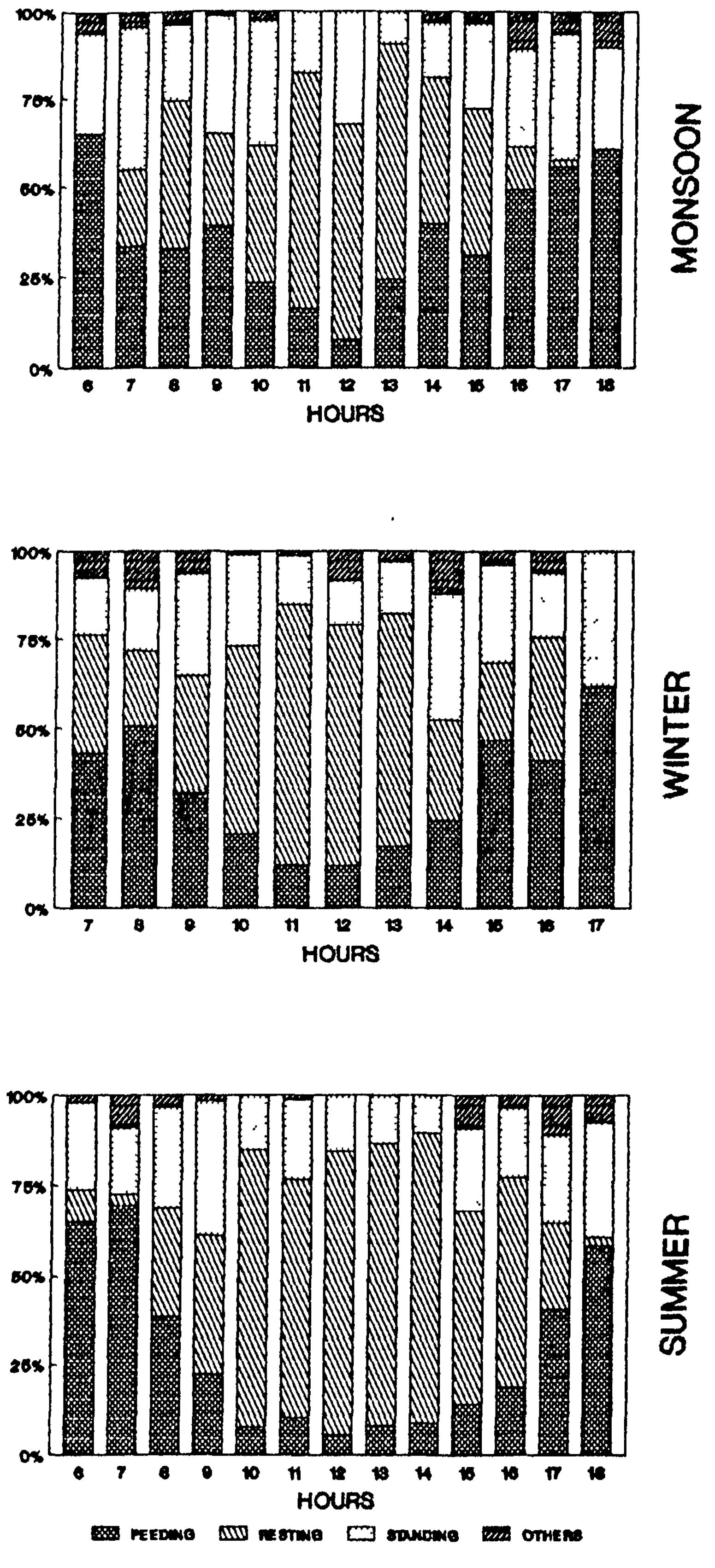


FIG 6.14

ACTIVITY PATTERN OF NILGAI



Activity pattern

Feeding

During monsoon 50% to 60% Nilgai were seen feeding during early hours (6-8) with a gradual decline in feeding activity towards noon. Feeding activity was observed to pick up again and reach its peak between 16 and 18 hours (60% animals).

During winter also there were two distinct peaks; one in the morning from 7 to 9 hours when around 40% to 50% animals were seen feeding and the other peak was noticed from 15 to 17 hours when more than 55% Nilgai were seen feeding (Fig 6.14).

During summer, Nilgai were seen feeding only in the early hours of the day and late in the evenings when more than 65% animals were seen feeding.

Resting

During monsoon the resting activity of Nilgai gradually increases from 9 hours and reached its peak from 11 to 13 hours when more than 65% animals were seen resting and from 14 hours it gradually declines.

During winter between 6 and 7 hours more than 30% Nilgai were seen resting and then it gradually declines and once again it gradually increased from 10 hours and reached its peak from 11 to 13 hours when more than 70% animals were seen resting (Fig 6.14).

FIG 6.15

THE FEEDING PATTERN OF NILGAI BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS

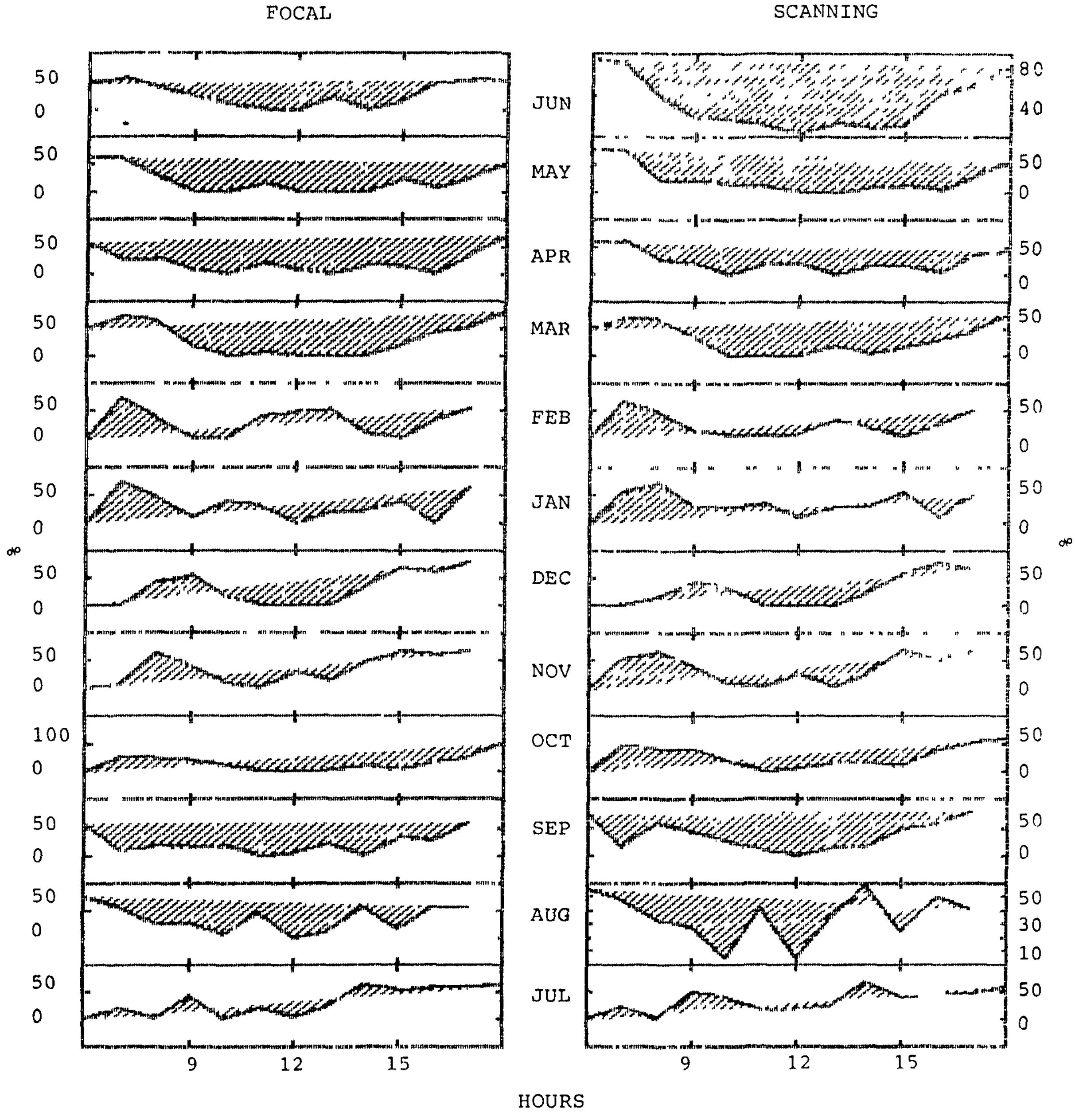
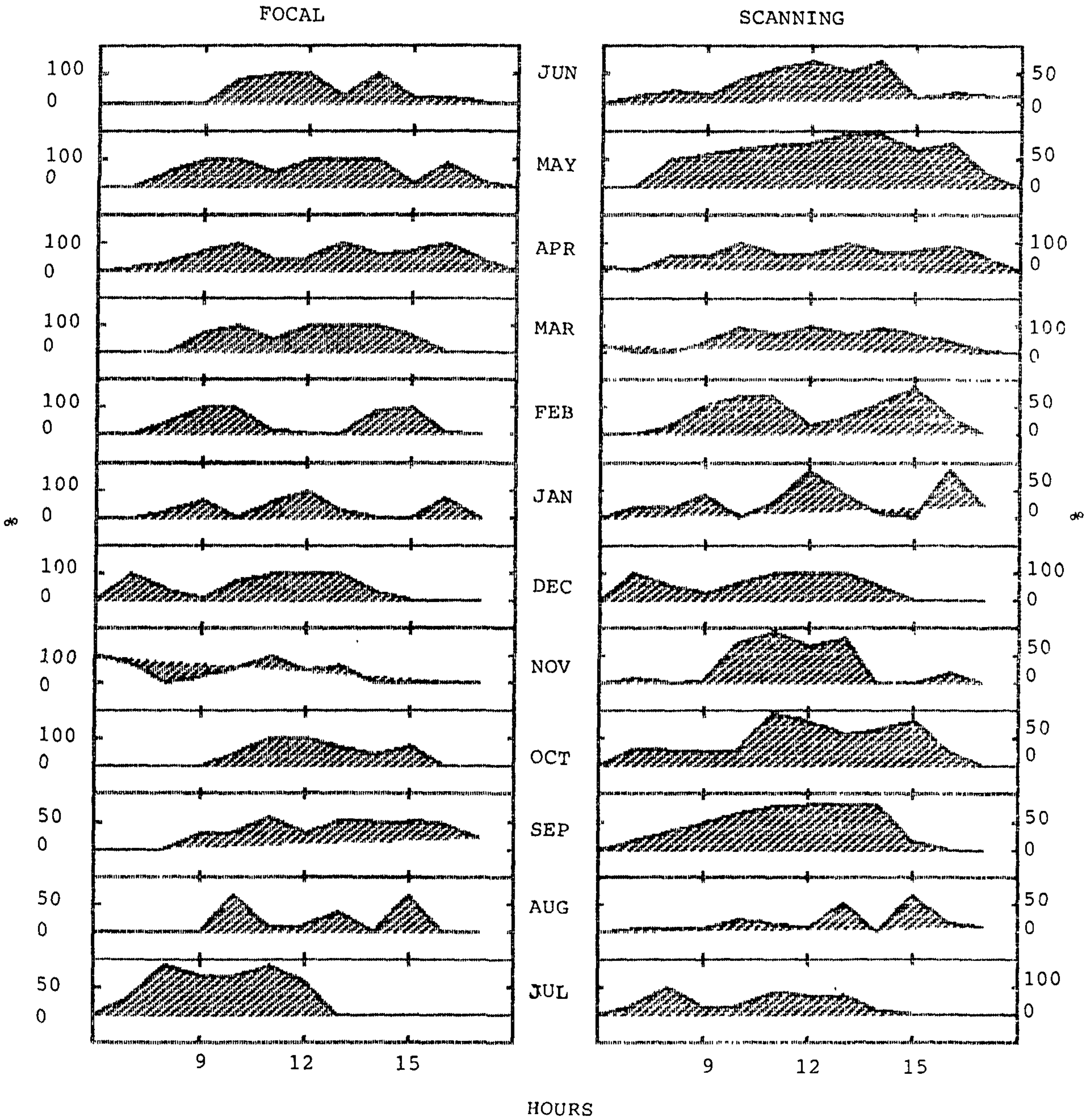


FIG 6.16

THE RESTING PATTERN OF NILGAI BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS



During summer Nilgai mostly started taking rest from 9 hours when 40% animals were seem resting. The resting activity of Nilgai during summer reaches its peak from 11 to 13 hours when more than 90% animals were seen resting.

The pattern obtained by focal and scanning methods, for feeding and resting activities of Nilgai, were similar for all the months (Fig 6.15 and 6.16).

6.3.5 Feral cattle

Time budget

The data collected during the observation period indicates that Feral cattle spent maximum time on feeding during monsoon (Table 6.1). Feeding activities of the Feral cattle showed two peaks; one between 6 and 9 hours (55%) and the other from 17 to 18 hours (46%) during monsoon. The pattern was almost the same during winter and summer, although the total time observed to be spend on feeding varied seasonally (Fig 6.17). There does not appear any significant correlation between feeding activity and temperature variations in different seasons.

Resting activity was less during early hours and late evening in all the seasons. The correlation between resting and temperature was not significant. No variation was noticed for resting activity when compared among season.

The average percentage of activity standing was noticed more during monsoon than other season. During this season owing to

FIG 6.17

TIME BUDGET OF FERAL CATTLE

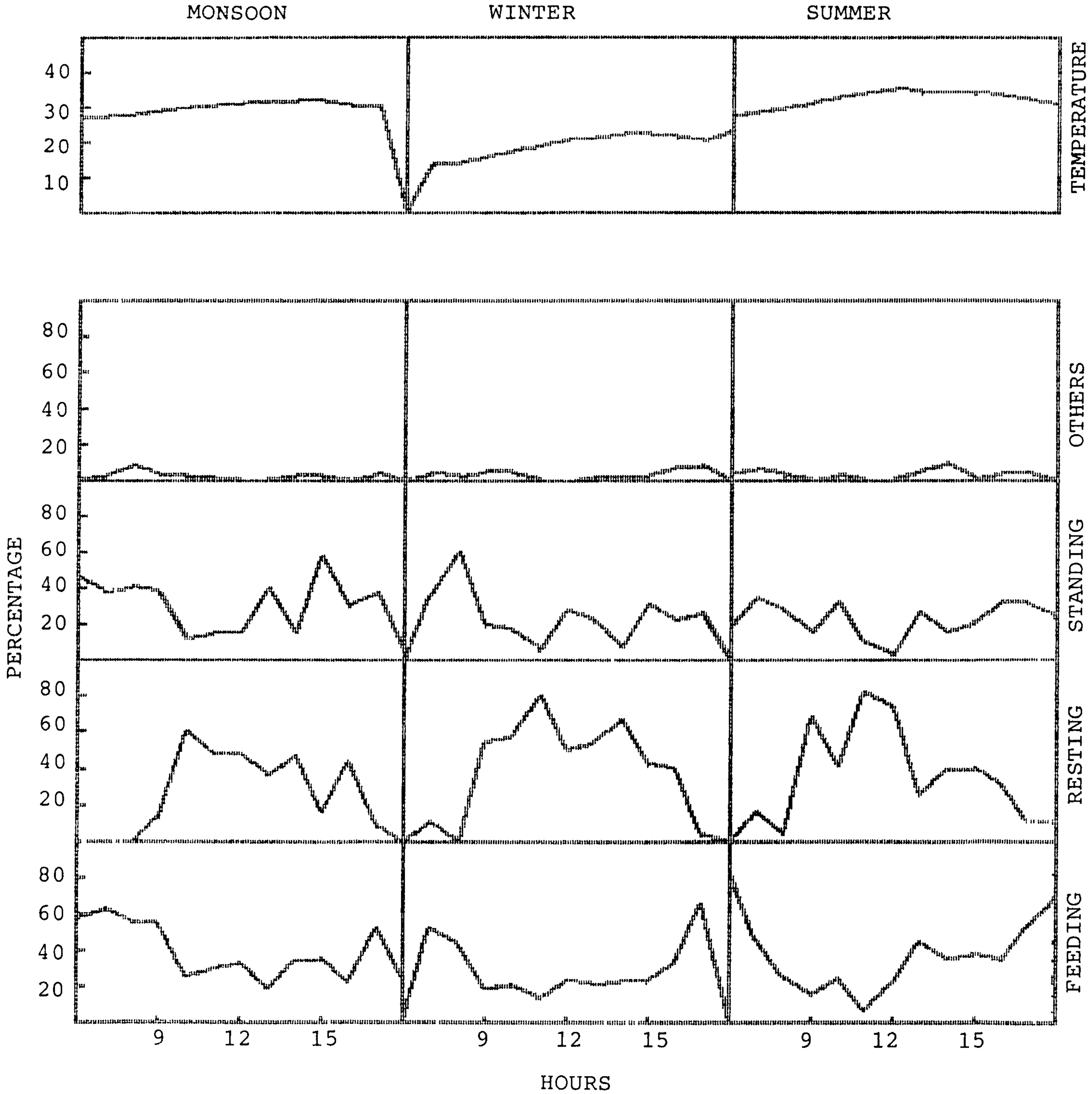
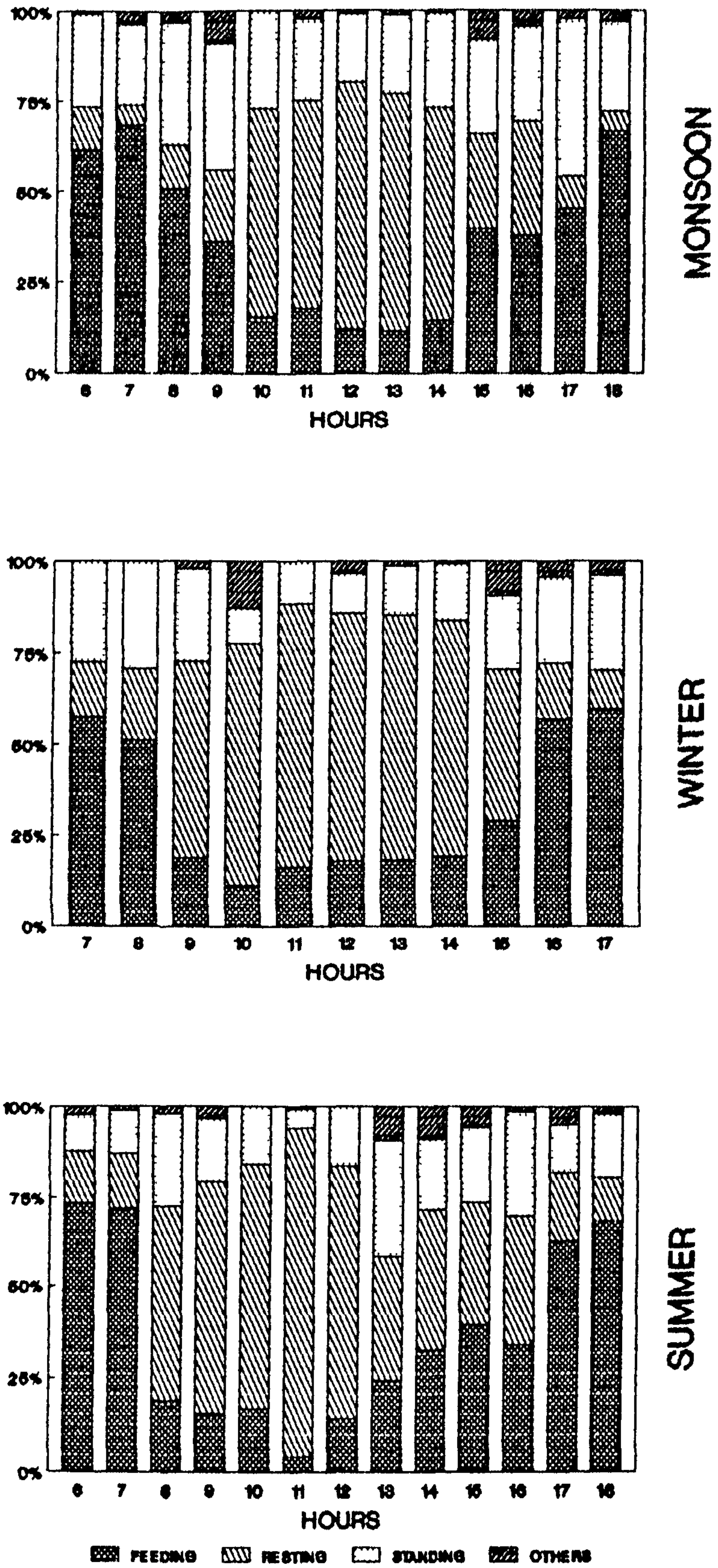


FIG 6.18

ACTIVITY PATTERN OF FERAL CATTLE



the presence of water in most of the areas animals did not prefer to rest or lie in the slushy mud. Both the activities standing and 'others', did not show any correlation with temperature. The time spent for standing showed a significant variation ($P < 0.05$) between monsoon and summer.

Activity pattern

Feeding

During monsoon more than 60% Feral cattle were seen feeding from 6 to 8 hours. The next peak of feeding activity was noticed again from 17 to 18 hours when 50-60% Feral cattle were seen feeding.

During winter two distinctive peaks of feeding activity of Feral cattle was noticed; One from 7 to 8 hours when more than 50% animals were seen feeding, and the next from 16 to 18 hours, when more than 55% animals were seen feeding.

During summer around 75% Feral cattle were seen feeding during early hours (6-7) and then their number gradually declined. The second peak was noticed from 17 to 18 hours when more than 60% animals were seen feeding (Fig 6.18).

Resting

The resting activity of Feral cattle during monsoon started increasing from 10 hours and reaches its peak at 12-14 hours when more than 65% animals were seen resting and then from 15 hours it gradually decreased.

FIG 6.19

THE FEEDING PATTERN OF FERAL CATTLE BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS

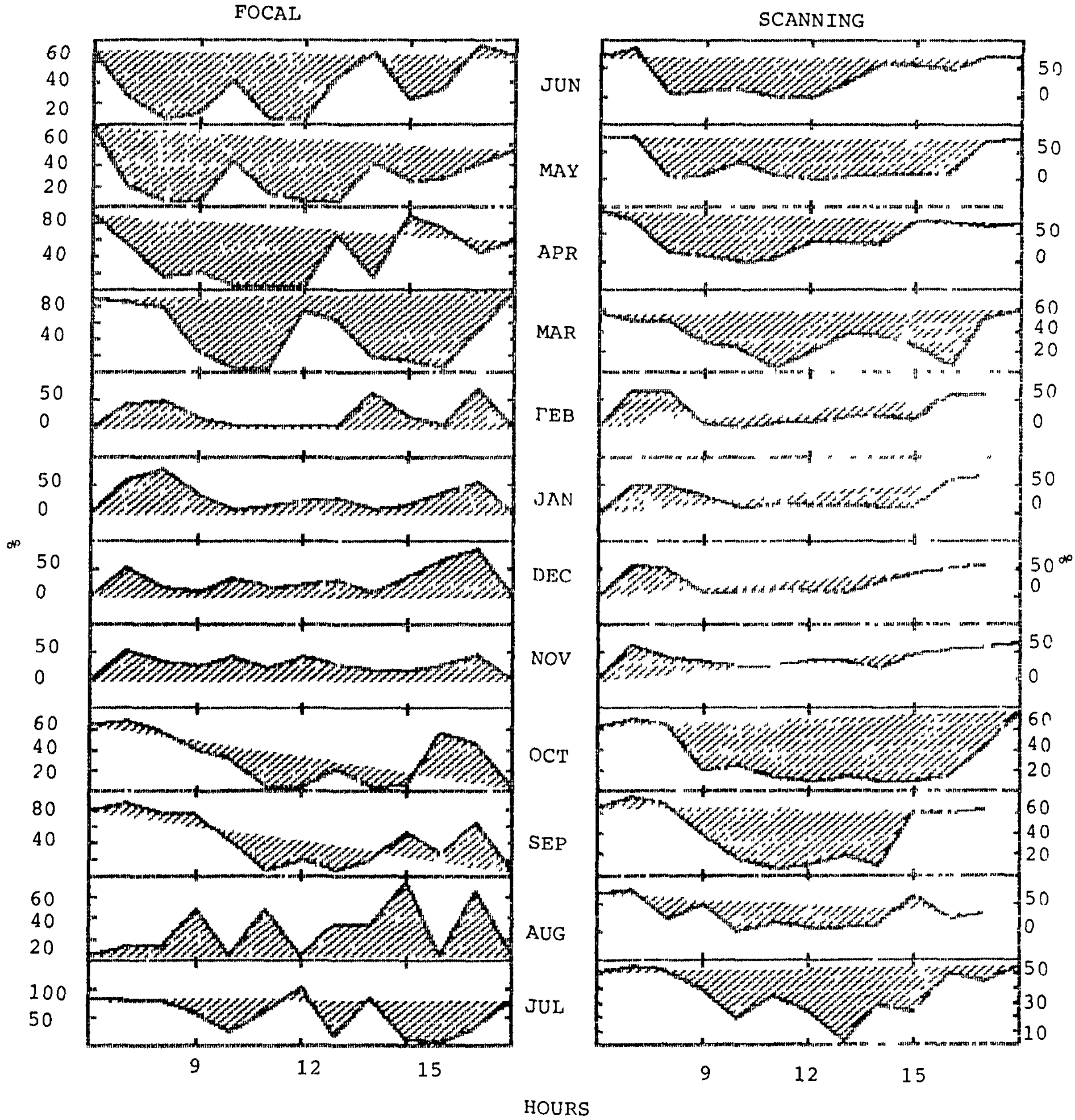
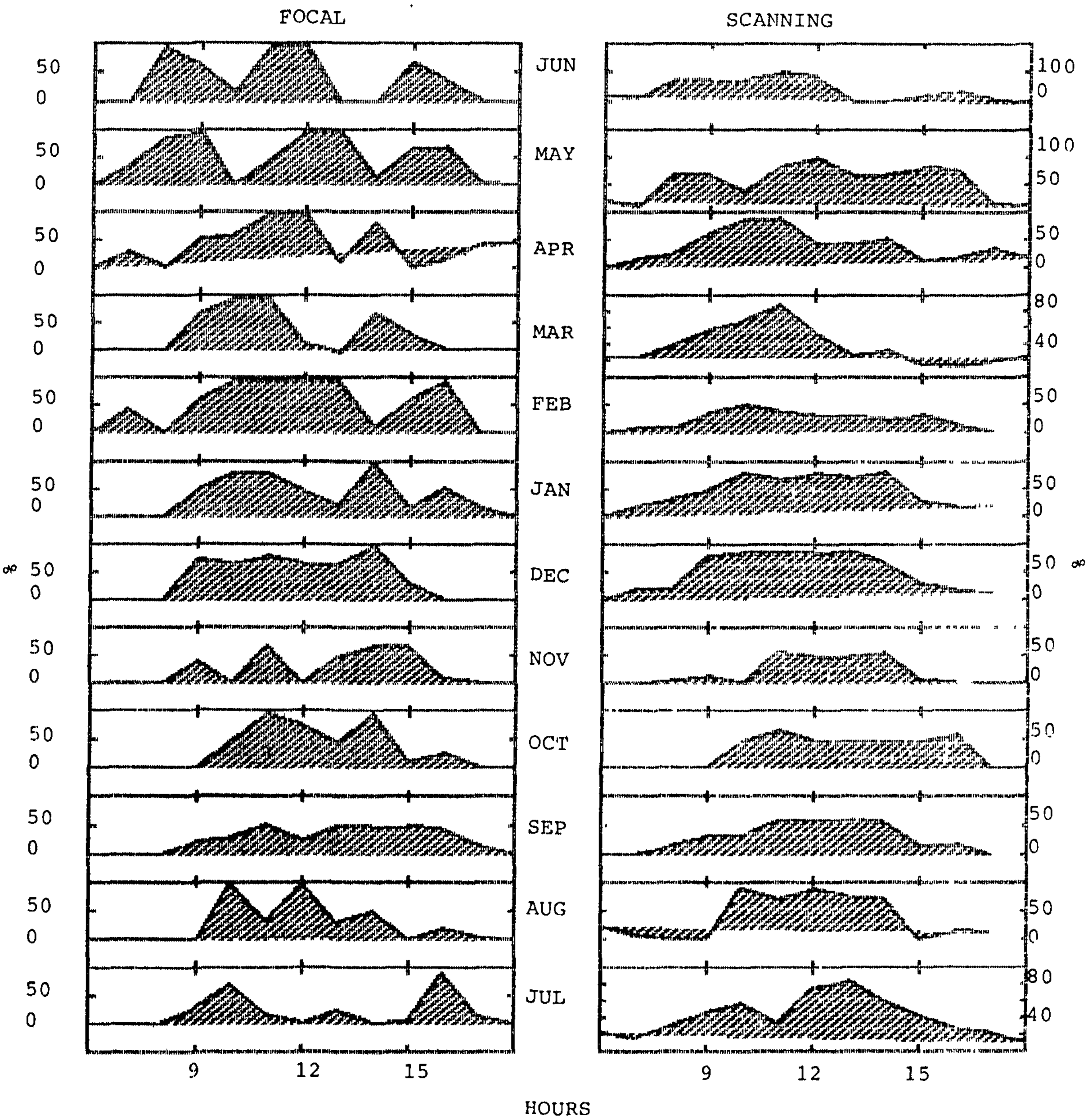


FIG 6.20

THE RESTING PATTERN OF FERAL CATTLE BY FOCAL AND SCANNING METHODS DURING DIFFERENT MONTHS



During winter the resting activity gradually increased from 9 hours and reaches its peak from 11 to 13 hours when more than 70% animals were seen resting.

In summer the resting activity started from 8 hours and reaches its peak at 10 hours when more than 65% animals were seen resting. This peak lasted till 15 hours and then it gradually declines (Fig 6.18).

The pattern obtained by focal and scanning methods, for feeding and resting activities of Feral cattle, did not show ~~the~~ similar trend for all the months (Fig 6.19 and 6.20). This may be due to large number of individuals in a group.

6.4 Discussion

During the present study comprehensive data on feeding rates, food - searching time and quantification of food ingested could not be collected because sufficient distance had to be maintained between the animals and the observer not to disturb their behaviour. One of the major shortcomings of this method was that no data could be collected for the activities performed during the night time. Occasional observations during ~~the~~ moon-li~~gh~~t showed that most of the ungulate species were inactive at night except during summer when some animals were seen grazing. Hence, in the discussion it is assumed that night time feeding did not affect the pattern shown by day time observation.

Though there are some interspecific differences in activity patterns and time budget, some broad generalization may be made. Ungulates in Keoladeo National Park feed most actively in the early hours of the day and then towards the evening and are comparatively inactive during noon and night. This general schedule continues throughout the year with slight variations in different seasons. Any deviation from this general pattern has its peculiar ecological reasons, which have been explained wherever necessary. Observations on Chital in Keoladeo National Park lead to more or less the same conclusions as drawn by Graff and Nichols (1966), Schaller (1967) and Ables (1974).

Behavioural studies on Sambar in different habitats indicate that this species is highly adaptable. Prater (1965) and Schaller (1967) found that Sambar in the Indian habitat is nocturnal while Richardson (1972) found it in Texas habitat to be diurnal, most active during afternoon and early evening. The present study in Keoladeo National Park however shows Sambar is diurnal and remains active from dawn to dusk with slight variations in three seasons.

It appears that Sambar switches over to nocturnal behaviour in habitats with human disturbance during day. In Keoladeo National Park where large number of tourists come in the day time particularly in winter, Sambar does not seem to be too much concerned with human disturbances partly because the habitats it uses in Keoladeo National Park are sufficiently distanced from the tourists zone and may be also because it has developed tolerance towards human beings after constant and regular exposure.

The author of this report estimated that Blackbuck spends 30% time on grazing (whole year's average) while Ables (1974) estimated it to be 40%. Prasad (1985) arrived at the figure of 30% to 40%. These differences are not significant and may be attributed to differences in methodology and habitat.

Schaller (1967) and Ables (1974) observed Blackbuck resting under the shade of trees when temperature rises. In the present study the animal was only occasionally seen resting under the trees to escape heat and similar observations have been reported by Prasad and Rao (1985).

Prasad (1985) found that Blackbuck spends more time on feeding in summer and he attributed it to the animals preference for fresh foliage which is scarce in summer. The present study in Keoladeo National Park indicates that there is no seasonal variation in time spent on feeding by Blackbuck. This difference may be due to the differences in habitats where the two studies were conducted.

Activity pattern of Nilgai according to the present study is similar to that reported by Sheffield (1983) and Dinerstein (1979). The only difference between the findings of the present study and that of Sheffield *et al.* (1983) is that I did not observe any feeding activity after sunset while Sheffield *et al.*(1983) did. This may be because observations during this study were not continued after sunset.

In general, all the ungulates spent on an average 25-35% day time for feeding. The larger ungulates spent more time than the smaller ones. Owen Smith (1982) showed that in ungulates there is a general decrease in feeding time with decreasing body size. A similar observation was reported by Fairall (1987) who found that Wildebeest spent around 25-30% time in feeding while it was 45% in Hartebeest.

Most of the species at Keoladeo National Park frequently fed during light rains showing no concern other than to rid the body off water as reported by Ables (1974) and Richardson (1972).

The trend in shade seeking behaviour and diurnal activity pattern can be related to factors causing heat stress and are more specifically defined as temperature and solar radiation. The lack of correlation of activities with temperature in the afternoon in most of the species suggests that incident solar radiation is more important controlling factor and that once this has declined the animal come out of shade and recommence feeding (Mitchel 1977). Hofmeyr(1981) found that use of shade by Wildebeest was more than the Hartebeest because of thin pelage in the former species while in the latter it has a thick pelage which has a lower absorbance value. This can explain the more frequent use of shade during resting by all ungulates except in Blackbuck which was seen resting in the open areas during mid day.

6.5 Summary

1) Significant variation in the time budget were noticed in the five species studied.

2) Time spent for feeding by each species is positively proportional to the body size.

3) Time spent on foraging in all the seasons is influenced by availability of food.

4) Though according to the present study there are some interspecific differences in activity pattern, some broad generalizations ca be made; ungulates in the Keoladeo National Park most actively feed in the early hours of the day and then towards the evening and are comparatively inactive during noon and night. This general schedule continues throughout the year with slight variations in different seasons.

5) The pattern obtained by focal and scanning methods, for feeding and resting activities of all the ungulates except Feral cattle, showed the similar trend for all the months.

7. FOOD AND FEEDING HABITS

7.1 Introduction

Studies on food and feeding habits of all wildlife species are of paramount importance for proper management. Animals, well nourished throughout their lives grow normally and are more vigorous and healthy than those with poor nutrition during part or all of their lives. Animals in good health generally have higher rates of reproduction and are more resistant to many types of mortality. On the other hand, animals with retarded growth and in poor health, as a result of malnutrition are prone to various forms of ailments and epidemics. Nutrition affects birth and mortality rates and thus plays an important role in dynamics of managed populations.

Carnivores being opportunistic feeders, generally do not exhibit marked food preferences. But herbivores which exist on crude foods with mainly carbohydrates and low proteins and other nutrients exhibit strong preferences for certain high quality foods.

Nutritional problems of wild herbivores are usually due to lack of foods of adequate quality. Animals may be malnourished or starving in a habitat where, superficially, food appears to be adequate because vegetation is available. However, a wildlife biologist familiar with wildlife species and its nutrition must recognize that preferred foods are absent and that animals are subsisting on unpalatable and poorly digestible foods (Bailey 1984).

According to Herry *et al.* (1982), the knowledge of food habits is essential for efficient range management. This information is required for optimal forage allocation to different types of herbivores, selecting types of grazing animals compatible with the range resources, selecting plant species for reseeding deteriorated ranges.

Quite a few studies have been done on the food habit of ungulates in various parts of the world. Most relevant and noteworthy of these studies are by Field (1968) who worked on the food habits of Buffalo, the waterbuck, *Kobus defassa* and Hippo, the warthog, *Phacochoerus aethiopicus* at Uganda. Drawe (1968), Chamrad *et al.* (1978) and John *et al.* (1980) on the food habits of White tailed deer *Odocoileus virginianus* in Texas. Rodger (1976) on the seasonal diet preferences of Impala *Aepyceros melampus* in South East Tanzania. Kessler (1981) on the food habits of Pronghorn *Antilocapra americana* in Montana; Pellow (1984) worked on the feeding ecology of Giraffe *Giraffa camelopardalis tippelskirchi*; Thill (1984) studied on the food habits of cattle and tame White tailed deer *Odocoileus virginianus*; Attwell and Bhika (1985) on the feeding ecology of Impala *Aepyceros melampus* in lake Kariba. Coppock *et al.* (1986) worked on the livestock feeding ecology at Kenya. Jackson and Giulietti (1988) on the food habits of Pampas deer *Ozotoceros bezoarticus* in Argentina.

Few studies have been done on the food habits of Indian species which include the work of Schaller (1967) who worked on Chital *Axis axis*, Sambar *Cervus unicolor*, Barasingha *Cervus duvauceli* and Gaur *Bos gaurus*. Berwick (1974) on Chital *Axis axis*, Sambar *Cervus unicolor* and Nilgai *Boselaphus tragocamelus*. Green (1985) worked on Himalayan Musk deer *Moschus chrysogaster*. Goyal *et al.* (1986) and Chattopadhya and Bhattacharya (1986) on Blackbuck *Antilope cervicapra*.

7.2 Methodology

Several methods have been employed by various workers to determine the food and feeding habits of free-living herbivores. (Anthony and Smith 1974, Michael *et al.* 1983, Gordon 1989). Each of these methods has its own limitations, advantages and disadvantages in a given situation. Keeping in view the feasibility and the objectives of the present study, following methods have been used.

(a) Direct observations, (with and without field glasses) of animals feeding freely in the field and recording the relative consumption of different plant species or their parts, as was done by Pellow (1984).

(b) Microscopic examination of materials obtained from the droppings collected in the field as described by Stewart (1967). This method being very elaborate and complex, however, needs a detailed description.

Although this method has got its advantages and disadvantages (Dearden 1975, Michael *et al.* 1983), it is widely used in analysing the food habits of herbivores (Crooker *et al.* 1959, Adams *et al.* 1962, Stewart 1967, Zyzmar and Urness 1969, Satakopan 1972, Voth and Black 1973, Anthony and Smith 1974, Scott and Dahl 1980, Gill*et al.* 1983 and Johnson 1983).

Microhistological method was employed during the present study because it was found to be the best one feasible under the circumstances and also because it gives a fairly reliable idea about qualitative and quantitative aspects of food of each species. But it suffers from certain disadvantages; the location of feeding cannot be known. some food items may remain unidentified and food habits differences between sexes and age groups cannot be found.

Preparation of reference material

The method followed by Scott and Dahl (1980) was adopted in this study because of the less complexity in the preparation of the reference material and the processing of fecal material.

Two chemical solutions were used in making slides:

(1) Hertwigs solution: It is a cleaning agent consisting of 270 gm chloral hydrate crystals, 10 ml of 1N Hcl and 60 ml glycerin. The glycerin and Hcl are mixed and then chloral hydrate crystals are added. The mixture is warmed over a spirit lamp until all the crystals of chloral hydrate ~~is~~ dissolved.

are

(2) Hoyers solution: It is a mounting medium containing 200 gm chloral hydrate, 50 ml water, 20 ml glycerin and 30 gm photo-purified gum arabic. First, glycerin is mixed with water and then chloral hydrate is added and the mixture is warmed until the crystals dissolve. The gum arabic is added to the solution which was then placed in a dark place until the gum was completely dissolved. This could take as long as a week.

Sample plants commonly used by ungulates were collected and soaked overnight in 95% ethanol to remove the pigments. The leaves were then blended in the mixture with hot water and dried. It was then stored in air tight tubes.

A small amount of blended material was spread over the slide. Three to four drops of Hertwigs solution were put on the material and the slides were held above a spirit burner for quick evaporation of the solution. When most (not all) of the solution evaporated, Hoyers solution was added and mixed with the material with the help of a needle. The cover slip was placed over it. Diagnostic characteristics of the reference materials were noted. A key to the identification of selected food plants is described in Appendix IX.

Collection and processing of faecal material for analysis

A small amount of dried blended sample was taken and slides were made following the same procedure, as was used for the preparation of reference slides. Slides were examined under microscope and analysed using the hit method (Middleton and Valk 1987, Sridharan 1988) and the percentage frequency of food items for different months was calculated.

Browse productivity and utilization

Production and utilization of browse species were studied only by very few (e.g. Shaffer 1963, Stickney 1966, Lyon 1968, Fitzgerald 1973, Ferguson and Michael 1977, Andrew *et al.* 1981, Grigal and Moody 1980). In India apart from the study on the productivity and utilization of browse species at Gir (Berwick 1974) no other serious work has yet been reported.

For determining the annual growth of unbrowsed twigs, following method was used.

Ten twigs; five fully grown and five still growing (termed by Berwick as 'current' and 'new' twigs respectively) were studied on each of the forty bushes under study. The length of each current twigs was measured and labeled with a metal tag and left intact on the bush. The new twigs were clipped (entire length) then measured and brought to the laboratory. The current twigs were remeasured on the bushes after a season of use to find out browse utilization.

The clipped twigs were weighed after being dried in an oven and the dry weight per unit length was calculated. The total number of new twigs on a bush was estimated by sampling through 50 cms x 50 cms quadrate; five such sampling were done on each bush and then multiplying the average number by the total area of the bush. Maximum height of each bush taken into consideration for these estimates was 2.5 m because this is the maximum height that can be reached by any animal under study.

Chemical analysis of major food plants

Major grasses and browse plants were clipped during the monsoon, winter and summer of 1988-89. They were analysed for protein, ether extract and calorific value.

Protein : Protein was estimated by using Phenol-reagent method (Oser 1979).

Ether extract: Ether extract was estimated following Allen *et al.* (1974).

Calorific value : Calorific value was estimated by bomb calorimeter.

Statistical analyses

The following statistical analyses were done using mainly statistical packages.

(a) Niche breadth: Niche breadth in terms of food plant (plant eaten by ungulate species) for each month were calculated by the following formula.

$$\text{Niche breadth} = B = 1/ \sum Pi^2$$

$$Bn = \frac{B - 1}{N - 1} \quad \text{(Lewins 1968)}$$

(b) Food diversity : Food diversity was calculated using Hill diversity index

$$N1 = e^{H1}$$

where, H^1 is Shanons' index (Ludwing and Reynolds 1988)

(c) Mann-Whitney 'U' test : The yearly comparison of the food of each ungulate was done by using Mann-Whitney 'U' test (Sokal and Rohlf 1969)

(d) Cluster analysis : The food similarity in the food preference by different ungulates was calculated by using Sokal and Michener (1958) method.

(d) Pearson correlation co-efficient : Correlation between the abundance of different food species and the percentage of plant fragments present in the droppings was calculated with the help of Pearson correlation co-efficient (r) value (Dawine and Heath 1970).

7.3 Results

7.3.1 Direct observation

Direct observation was made for each species along the transects laid through various habitats of the park. The transects were traversed four to five times in a month at different hours of the day. The total number of animals feeding on a particular plant species were recorded and tabulated (Table 7.1).

CHITAL

Out of 2193 observations made on chital, 503 times the animals were found feeding; 67.6% animals were seen grazing and 32.4% were seen browsing (Table 7.2). Among the grass species Chital preferred mostly *Cynodon dactylon* and *Sporobolus* spp. while *Acacia nilotica* and *Capparis sepiaria* were found to be the most commonly browsed species.

SAMBAR

A total of 126 observations were made on Sambar, 27 times the animals were found feeding. Grazing constituted 77.7% while browsing 22.2%. *Paspalum distichum* was highly preferred by Sambar. Among the browse species like Chital, Sambar also preferred *Acacia nilotica*.

Table 7.1

Major food of ungulates in percentage by direct observations

	Chital	Sambar	Blackbuck	Nilgai	F.cattle	W.boar
A.nilotica	4.49	13.39	0.00	12.66	0.61	0.00
B.roxburghii	0.32	0.00	0.00	3.45	0.00	0.00
C.decidua	1.65	0.00	0.00	0.06	0.07	0.00
C.sepiaria	5.52	0.00	0.00	4.80	0.76	0.00
C.dactylon	27.74	7.09	35.59	7.67	17.18	6.52
Cyperus spp.	6.86	7.09	7.47	1.09	3.95	38.26
D.bipinnata	3.23	0.00	3.20	13.04	16.50	0.00
D.annulatum	6.54	1.57	17.08	7.23	11.42	0.00
Echinocloa spp.	3.78	0.00	2.85	1.25	3.86	7.39
Eragrostis spp.	2.13	0.00	0.71	0.90	1.56	0.00
Isolema laxum	0.16	0.00	4.27	0.32	0.10	0.00
P.disticum	5.28	48.03	14.95	29.67	20.28	1.30
Paspaldium spp.	0.00	0.00	0.00	0.32	1.05	0.43
P.juliflora	2.76	0.00	0.00	3.71	0.05	3.91
Scirpus spp.	0.95	3.15	1.07	0.77	3.44	34.78
S.persica	1.42	0.00	0.00	2.88	0.85	0.00
Sporobolus spp.	18.99	12.60	11.39	3.01	9.18	0.43
V.zizanioides	2.36	0.00	1.42	3.20	7.74	0.00
Z.mauritiana	3.70	0.00	0.00	2.43	0.12	6.96
Misc.	2.13	7.09	0.00	1.66	1.27	0.00

Table 7.2

Feeding habits of ungulates

Species	Total No.of observations	No.of observation on feeding	Percentage of animals grazing	Percentage of animals browsing
Chital	2193	503	67.6	32.4
Sambar	126	27	77.77	22.22
Blackbuck	270	113	100.00	0
Nilgai	1295	407	51.36	48.64
Feral cattle	6932	1325	96.08	3.92
Wild boar	195	41	100.00	0
Total	10111	2416		

BLACKBUCK

Out of 270 observations made on Blackbuck, 113 times they were seen grazing. No animal was seen browsing. The maximum number of Blackbuck was seen feeding on *Cynodon dactylon* followed by *Dicanthium annulatum*, *Paspalum distichum* and *Sporobolus* sp.

NILGAI

Altogether 1295 observations were made on Nilgai, out of which 407 were on feeding. Out of this, during the observation 51.36% animals were seen grazing and 48.64% while browsing. The most preferred food of Nilgai among grass species was *Paspalum distichum* followed by *Desmostachya bipinnata*, *Cynodon dactylon* and *Dicanthium annulatum*. Among browse species *Acacia nilotica* was most preferred followed by *Capparis sepiaria* and *Balanites roxburghii*.

FERAL CATTLE

Altogether 6023 observations were made on Feral cattle out of which 1325 were on feeding. 96.08% was grazing while only 3.92% browsing. The maximum number of Feral cattle fed on *Paspalum distichum* and *Cynodon dactylon* which was followed by *Desmostachya bipinnata* and *Dicanthium annulatum*. A few Feral cattle browsed on *Acacia nilotica* and *Capparis sepiaria* during the summer of 1987 which was the drought year.

<u>WILD BOAR</u>

Out of 195 observations made on Wild boar only 41 animals were seen grazing. They were never seen browsing. The most preferred food of Wild boar was the tubers of *Cyperus* spp. and *Scirpus* spp. (Table 7.1).

7.3.2 Plant material in faeces

Epidermal fragments were classified into woody species (including shrubs and trees), grasses, herbs, aquatic macrophyte and agricultural crops. Samples of agricultural crop were collected from the nearby villages for preparation of reference slides.

<u>CHITAL</u>

The droppings collected during 1987-88 contained fragments of 33 plant species while the 1988-89 collection had fragments of 35 plant species. Out of these 11 were browse species, 17 were grasses, 6 were herbs and one aquatic macrophyte (Appendix I). No significant variation in the food preference of Chital was observed from 1987-88 to 1988-89.

Woody plants

Epidermal fragments of the leaves of trees and shrubs were dominant in the faeces (31-33%) during summer between March and June but their levels were lowest (2%) during monsoon between July and October. During winter it varied from 13% to 21%

FIG 7.1

FOOD PREFERENCE OF CHITAL

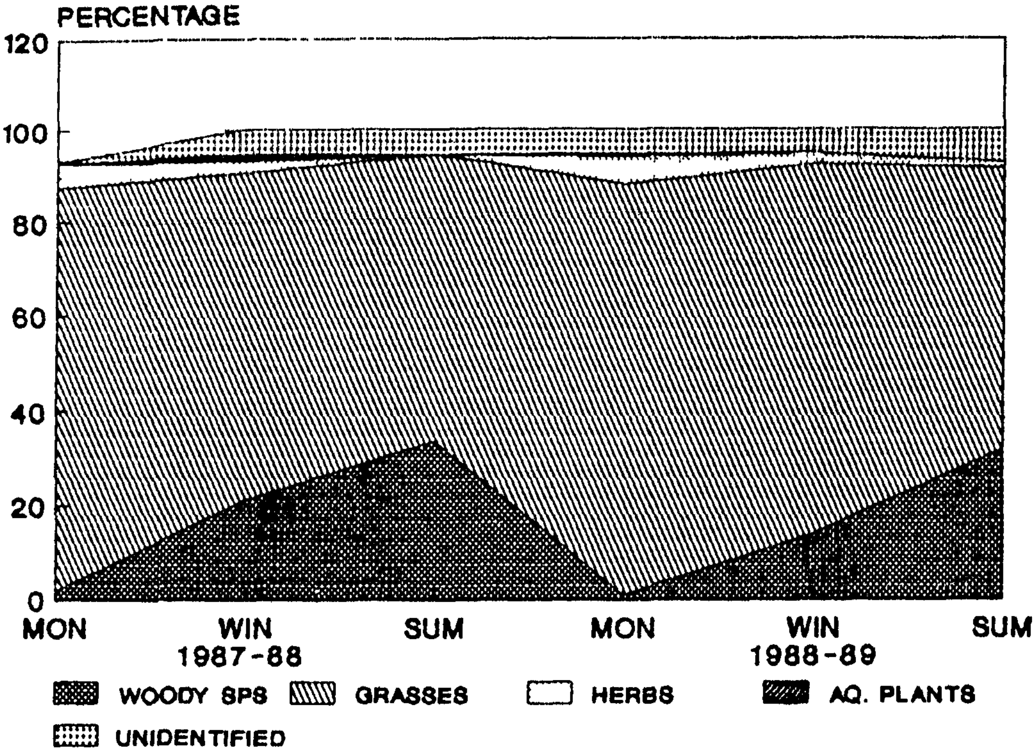
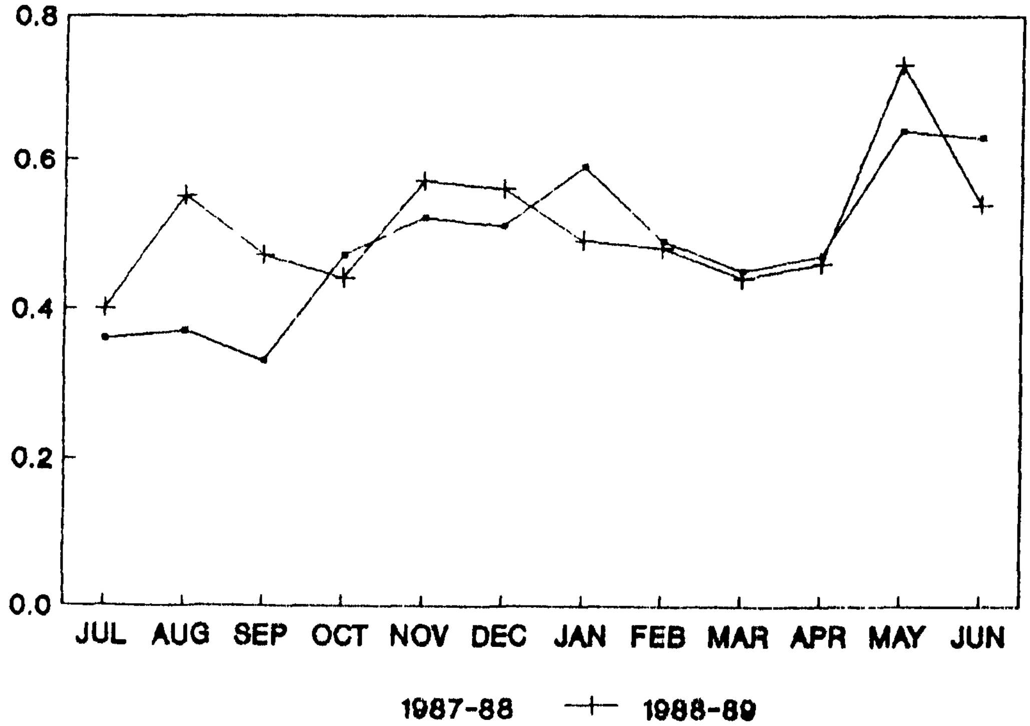


FIG 7.2

NICHE BREADTH OF CHITAL BASED ON FOOD PLANTS



(Fig 7.1). The higher frequency of parts of woody species during summer suggests that lot of animals depend on browse species when grasses are scarce. The most preferred species among the browse seems to be *Acacia nilotica* and *Capparis sepiaria*.

Grasses

Grasses were eaten all the year round (Fig 7.1), even in summer, when grasses are scarce. The proportion of grasses in the faeces during summer was 59-60% which increased to 85-86% during monsoon. The preference for grass species all round the year is due to their abundance. Maximum amounts of *Cynodon dactylon* and *Sporobolus* sp. were found in the droppings during both the years. The former was slightly more during 1987-88 while the later was slightly more during 1988-89.

Herbs

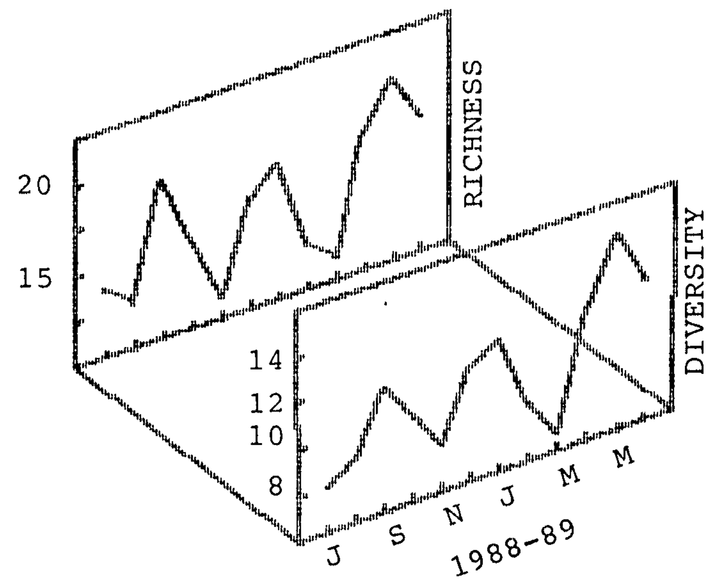
Herbs constituted 1-6% of faecal fragments. In both the years, the highest frequency was in the monsoon. During the summer of 1987-88 no fragments of herbs could be found in the faeces. *Cyanotis* sp. and *Commelina* sp. were proportionately higher as compared to other herbs.

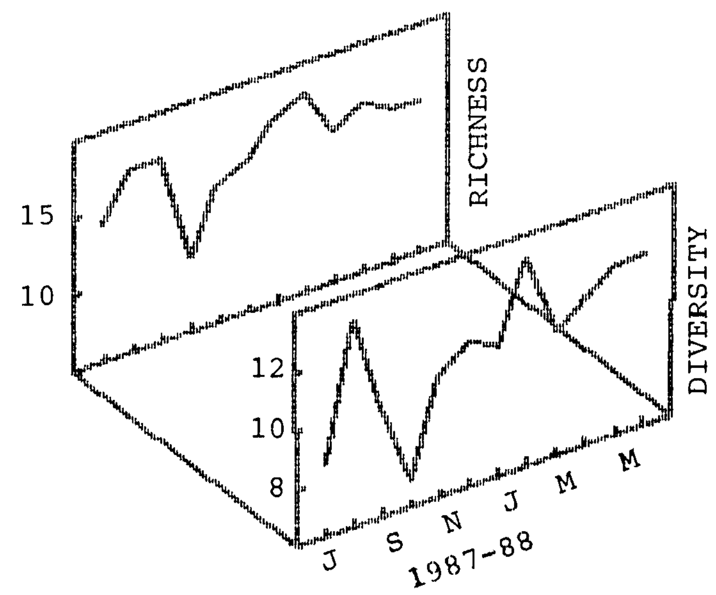
Aquatic macrophytes

Epidermal fragments of aquatic macrophyte were rarely present in the faeces.

FIG 7.3

DIET RICHNESS AND DIVERSITY OF CHITAL





Niche breadth

The niche breadth calculated in terms of food varied from 0.33 in September to 0.64 in May during 1987-88 while it was slightly higher during 1988-89 which varied from 0.4 in July to 0.73 in May (Fig 7.2). In both the years the niche breadth was wider during summer as Chital also feed on some of the browse species. Niche breadth did not vary in between two years.

Food diversity

Food diversity of Chital did not vary in between the two years. During 1987-88 the maximum diversity was noticed in August (13.1) while least was in October (6.96), whereas during 1988-89 the maximum was in May (19.59) and minimum in March (6.77) (Fig 7.3).

SAMBAR

Fragments of 29 species of plants were recorded from the droppings of Sambar during both the years, 1987-88 and 1988-89. This includes 6 browse species, 13 grass species, one herb and 9 aquatic macrophytes (Appendix II). The food of Sambar did not vary between the two years.

Woody plants

Woody plants in the faeces were maximum during summer (26.31%) and minimum in monsoon (12%) during 1987-88 , whereas the minimum (10%) in winter of 1988-89 (Fig 7.4). During summer

FIG 7.4

FOOD PREFERENCE OF SAMBAR

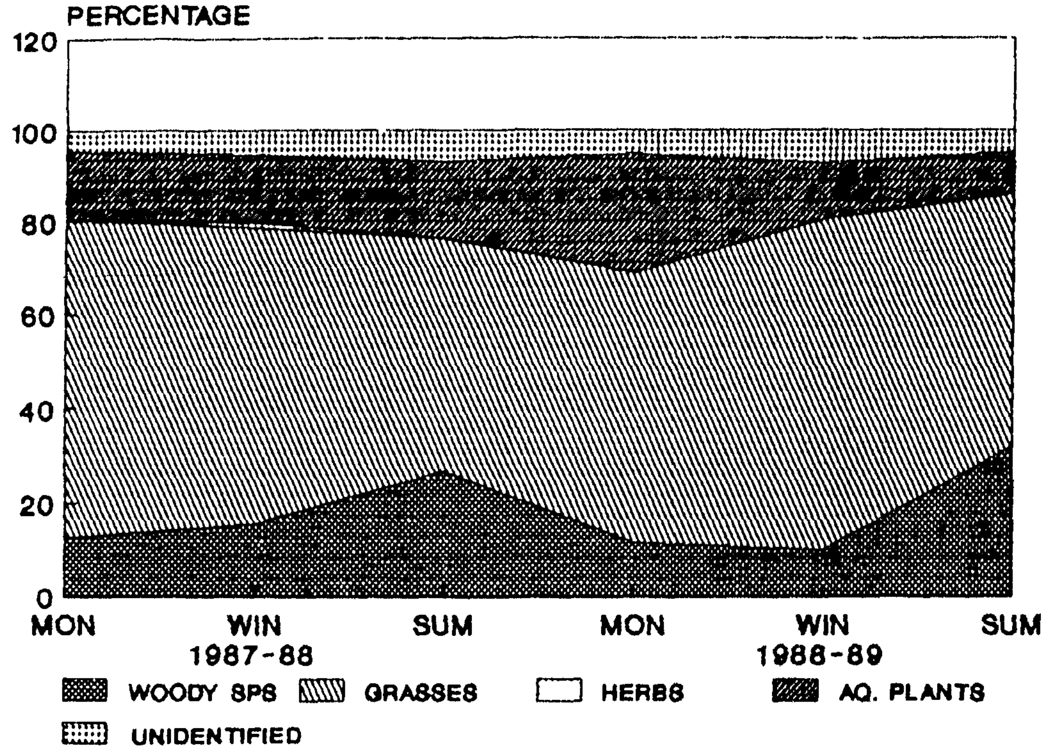
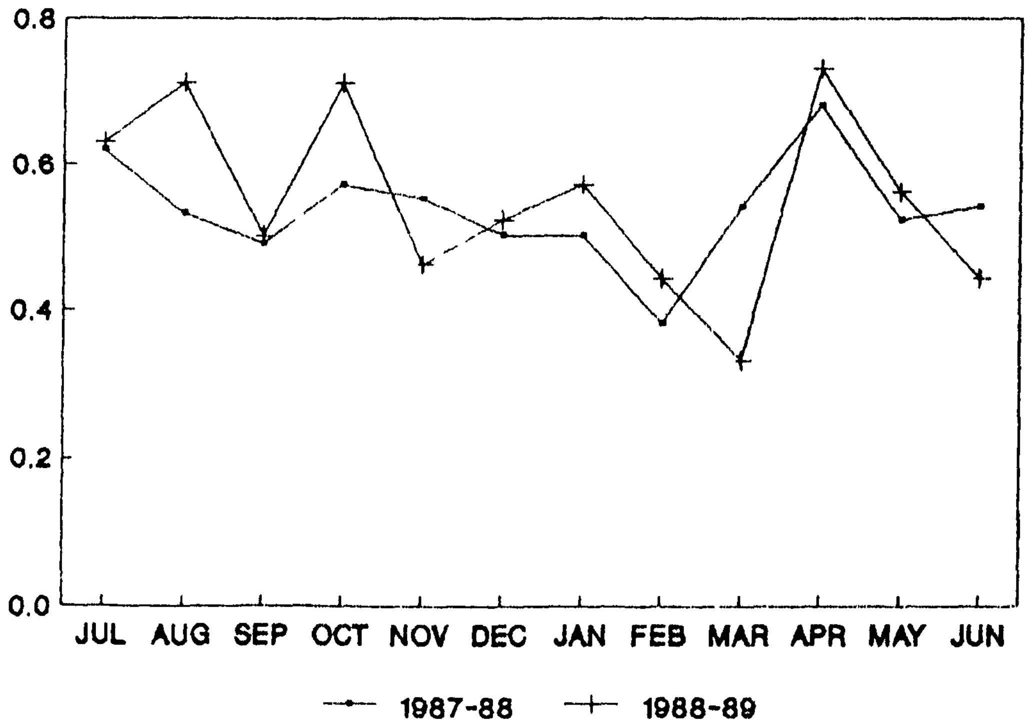


FIG 7.5

NICHE BREADTH OF SAMBAR
BASED ON FOOD PLANTS



when the wetland gets dried up the animals move towards the terrestrial area where they feed on browse species along with the grass species. The major woody species eaten were *Acacia nilotica* and *Capparis sepiaria*.

Grasses

In 1987-88 during monsoon and winter the grass species were dominant (62-67%) while these were very low in summer (49.45%), whereas during 1988-89 the maximum was in winter (70%) while during monsoon and summer it did not differ much (54-57%). The major grass species seem to be preferred by Sambar was *Paspalum distichum* followed by *Scirpus* sp. in 1987-88 and *Cyperus* sp. in 1988-89.

Aquatic macrophytes

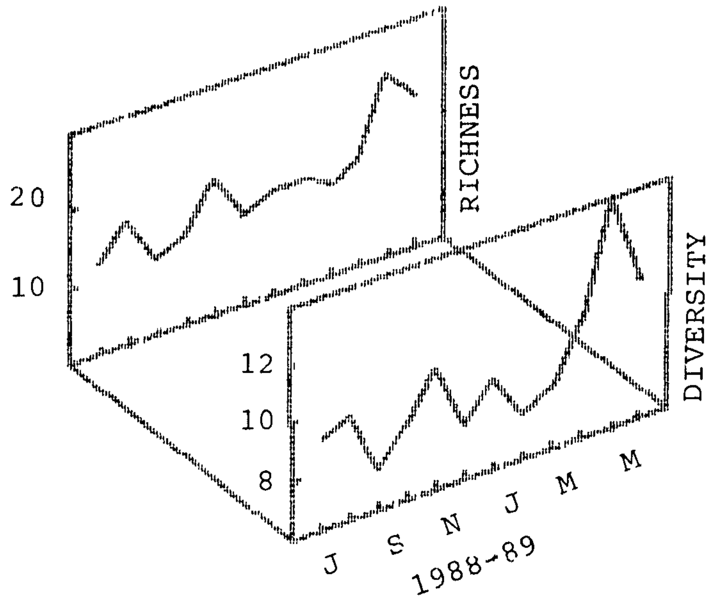
During 1987-88 the proportion of macrophyte was almost constant in all the seasons, varying from 14-16%. But in 1988-89 it increased progressively from 9% to 25% from summer to monsoon. The proportion was small during the former year because of the non-availability of macrophyte after the drought while in the latter year it was preferred which may be due to the high protein and caloric value. This is supported by evidence presented in the next section. Among the aquatic macrophytes the most preferred ones appear to be *Ipomoea* sp. and *Hydrilla* sp.

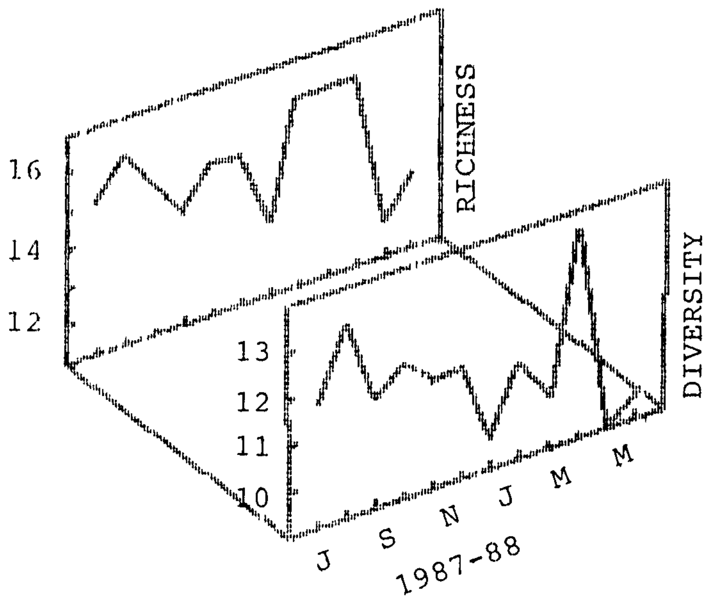
Herbs

No herb fragments were seen in the faeces of Sambar except in the winter of 1987 when it was seen in a very low proportion.

FIG 7.6

DIET RICHNESS AND DIVERSITY OF SAMBAR





Niche breadth

The niche breadth of Sambar based on the diet did not vary much in between the two years. During 1987-88 the niche breadth varied from 0.38 in January to 0.68 in April while during 1988-89 it ranged from 0.33 in February to 0.73 in April (Fig 7.5). The niche breadth was higher during monsoon because of the abundance of food in aquatic areas where very few other ungulates grazed.

Food diversity

The food diversity of Sambar differed significantly ($P<0.05$) in between the years. During 1987-88 it ranged from 9.06 in May to 13.17 in August while during 1988-89 it varied from 7.43 in September to 13.89 in May (Fig 7.6).

BLACKBUCK

Fragments of 15 plant species (Appendix III) were identified in the faeces of blackbuck and all of them happened to be of grass species (Fig 7.7). Out of these grasses *Cynodon dactylon* was the most common species in the epidermal fragments in both the years. The next preferred food was *Sporobolus* sp. followed by *Dicanthium annulatum* and *Paspalum distichum*. The same trend was noticed in both the years.

Niche breadth

The niche breadth of Blackbuck based on the variety of food item consumed varied significantly ($P < 0.05$) in between the two

FIG 7.7

FOOD PREFERENCE OF BLACKBUCK

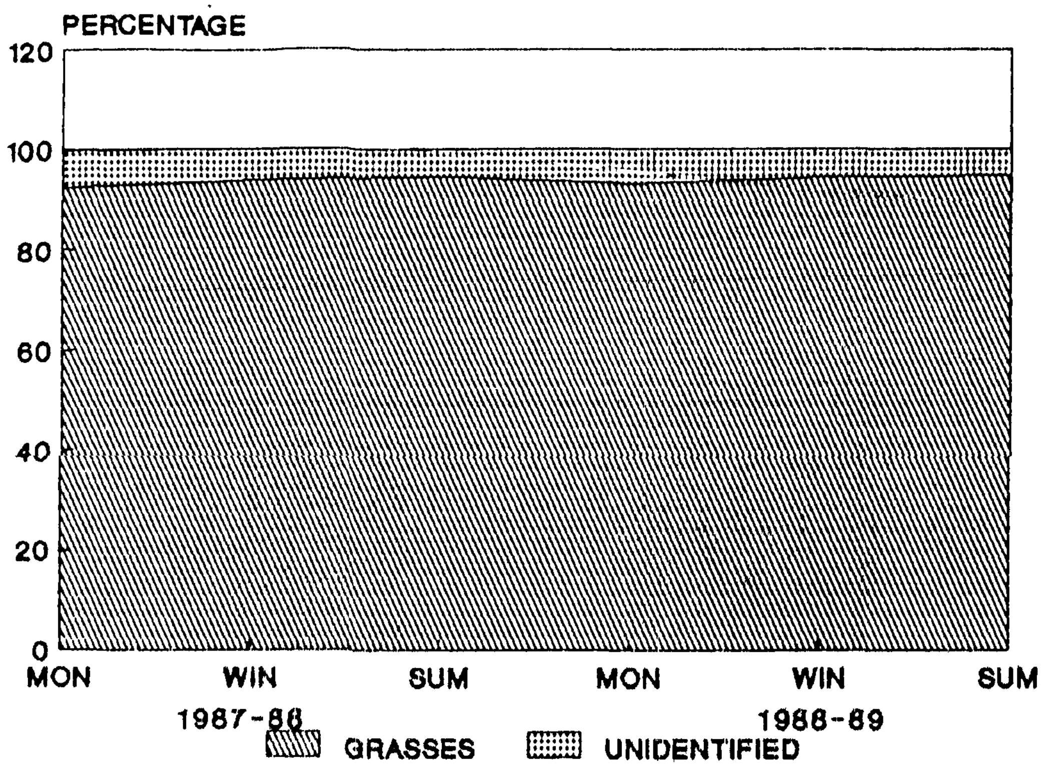


FIG 7.8

NICHE BREADTH OF BLACKBUCK BASED ON FOOD PLANTS

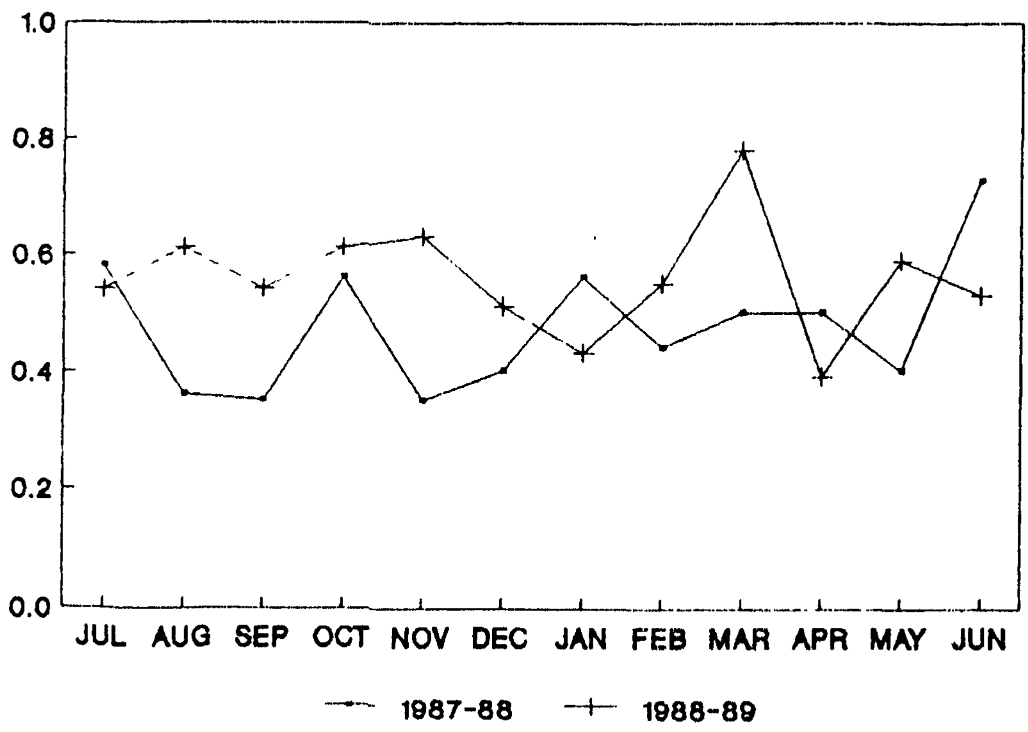
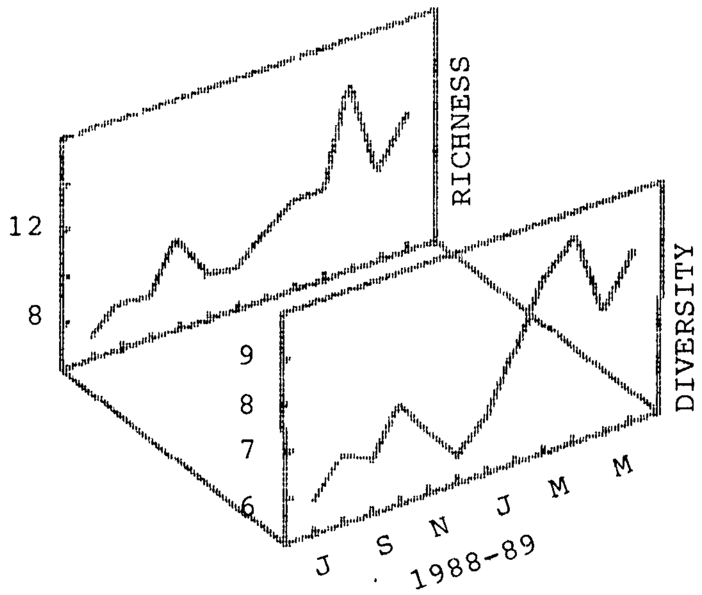
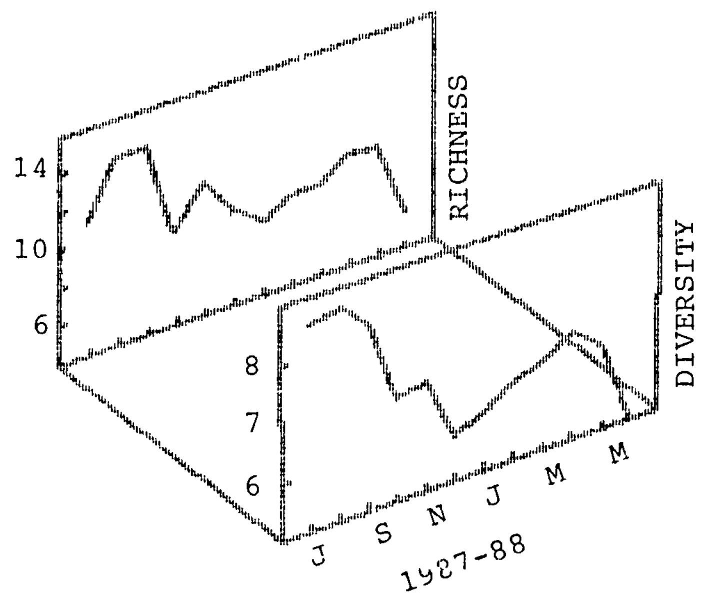


FIG 7.9

DIET RICHNESS AND DIVERSITY OF BLACKBUCK





years. During 1987-88 it varied from 0.35 in September to 0.73 in June while during 1988-89 it ranged from 0.39 in April to 0.78 in March (Fig 7.8). The breadth during the year 1987-88 was narrower than 1988-89 was due to the preference of only few species like *Cynodon dactylon* and *Sporobolus* sp. while in the year 1988-89 besides *Cynodon dactylon* and *Sporobolus* sp., *Dicanthium annulatum* and *Paspalum distichum* were present in the diet of Blackbuck.

Food diversity

The food diversity of Blackbuck did not vary much in between the two year. It varied from 5.06 in June to 8.66 in August, 1987-88 while it did so from 5.6 in December to 9.47 in April, 1988-89 (Fig 7.9).

NILGAI

Fragments of 40 plant species were identified through the analysis of droppings of Nilgai. This includes 9 browse, 17 grass, six herbs, two aquatic macrophytes and six agricultural crops (Appendix IV). There was no significant variation in the preference of food of Nilgai between the two years.

Woody plants

Epidermal fragments of the leaves of trees and shrubs were comparatively more during winter and summer of 1987-88 than in 1988-89. In the former year it varied from 31-35% , whereas in the latter year it varied from 24-25% (Fig 7.10). The most

FIG 7.10

FOOD PREFERENCE OF NILGAI

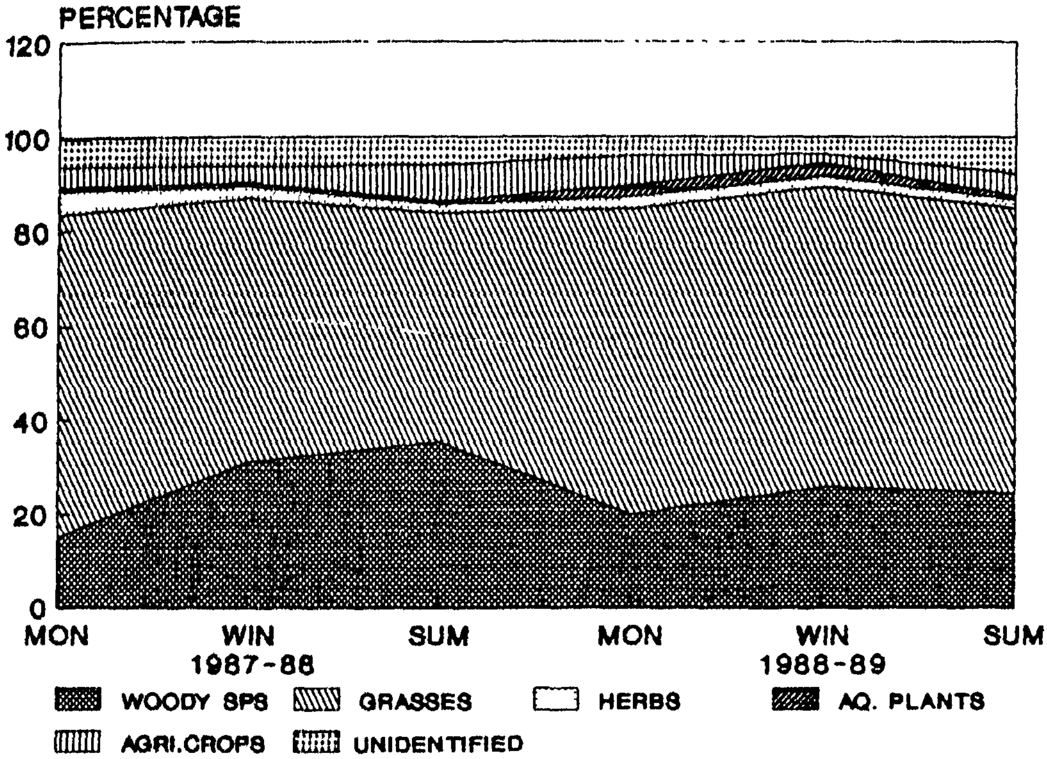
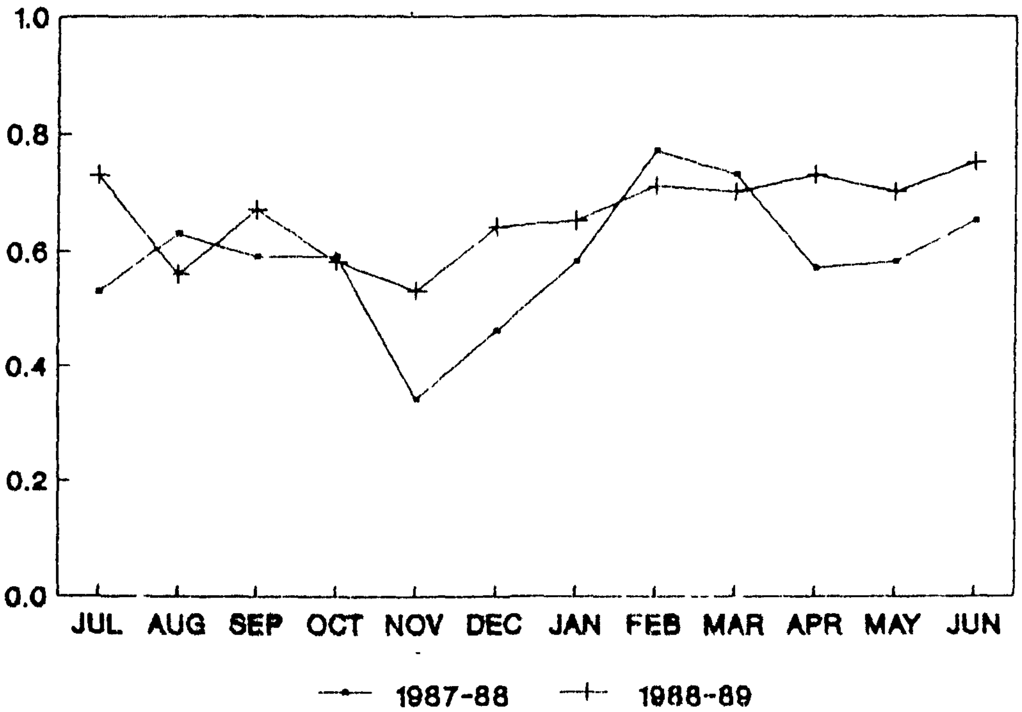


FIG 7.11

NICHE BREADTH OF NILGAI
BASED ON FOOD PLANTS



preferred species among the browse seem to be *Acacia nilotica* and *Capparis sepiaria*.

Grasses

The Nilgai fed on grass all through the year. The proportion of grass in the faeces increased from 48-60% in summer to 64-68% in monsoon. *Cynodon dactylon*, *Sporobolus* sp. and *Paspalum distichum* appear to be the preferred species of the food of Nilgai.

Herbs

Herbs constituted 2-6% of faecal fragments. In both the years the highest was noticed in the monsoon. *Cyanotis* sp. and *Trianthema* sp. were proportionately higher than other herbs.

Aquatic macrophytes

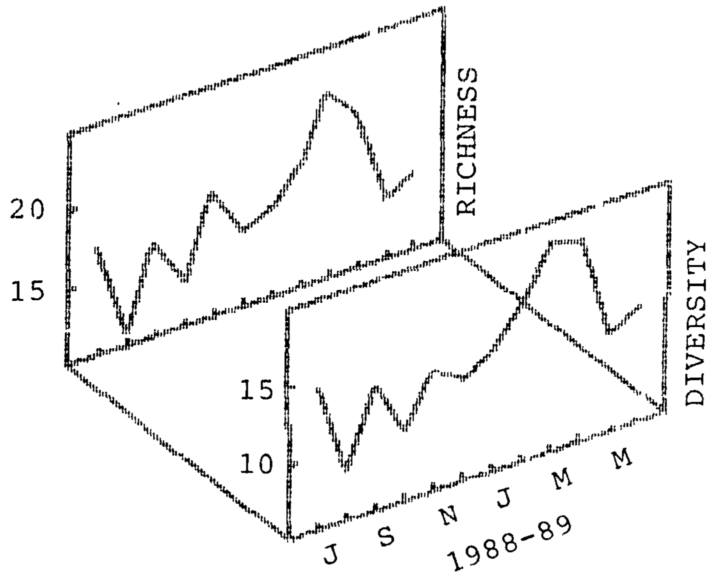
Aquatic macrophytes did not exceed more than 3% of epidermal fragments. Compared to 1987-88, the samples of 1988-89 had a large proportion of aquatic macrophytes. The most preferred among them appears to be *Ipomoea aquatica*.

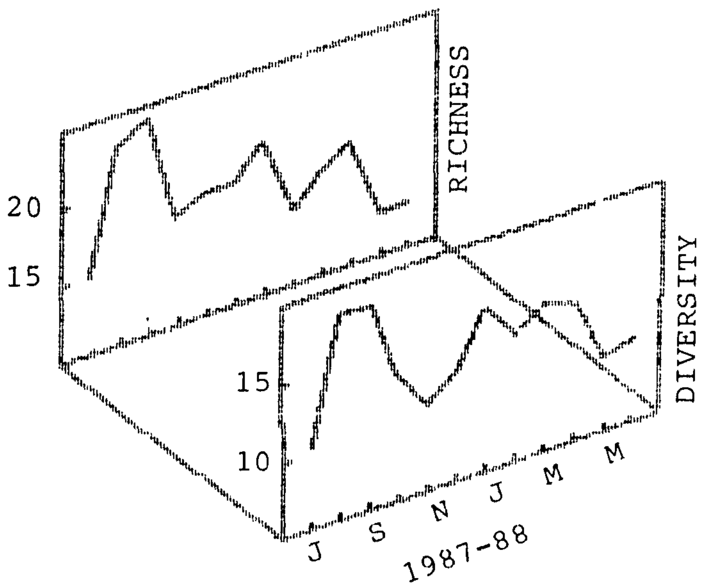
Agricultural crops

Fragments of agricultural crops were seen in all the seasons during both the years, although in negligible quantities. During 1987-88 the maximum was noticed in Summer (8%), whereas in 1988-89 it was in monsoon (6%). During monsoon *Sorghum vulgare*

FIG 7.12

DIET RICHNESS AND DIVERSITY OF NILGAI





(Jowar) and *Pennisetum typhoides* (Bajra) were seen in the food of Nilgai while during winter only *Brassica campestris* (Mustard) and during summer *Cicer arietinum* (Chana) and *Pisum sativum* (Matar) were recorded.

Niche breadth

The niche breadth based on food items of Nilgai varied significantly ($P < 0.05$) between two years. During 1987-88 it varied from 0.34 in November to 0.77 in February while during 1988-89 from 0.53 in November to 0.75 in June (Fig 7.11). In both the years the niche breadth was wider during summer as the animal were seen browsing besides grazing. Fragments of a wider variety of plant (*Acacia nilotica*, *Capparis sepiaria*, *Capparis decidua*, *Prosopis juliflora*, *Acacia* pods) were found in the droppings collected during summer than of those collected in other seasons which contained only *Acacia nilotica* and *Capparis sepiaria*.

Food diversity

The food diversity of nilgai did not vary between the years. During 1987-88 it varied from 9.88 in June to 18.41 in August while during 1988-89 it ranged from 9.76 in October to 18.72 in March (Fig 7.12).

FERAL CATTLE

Fragments of 31 species of plants were identified in the dungs of Feral cattle during 1987-87 while it was comparatively low (21 species) during 1988-89 (Appendix V). During the former

FIG 7.13

FOOD PREFERENCE OF FERAL CATTLE

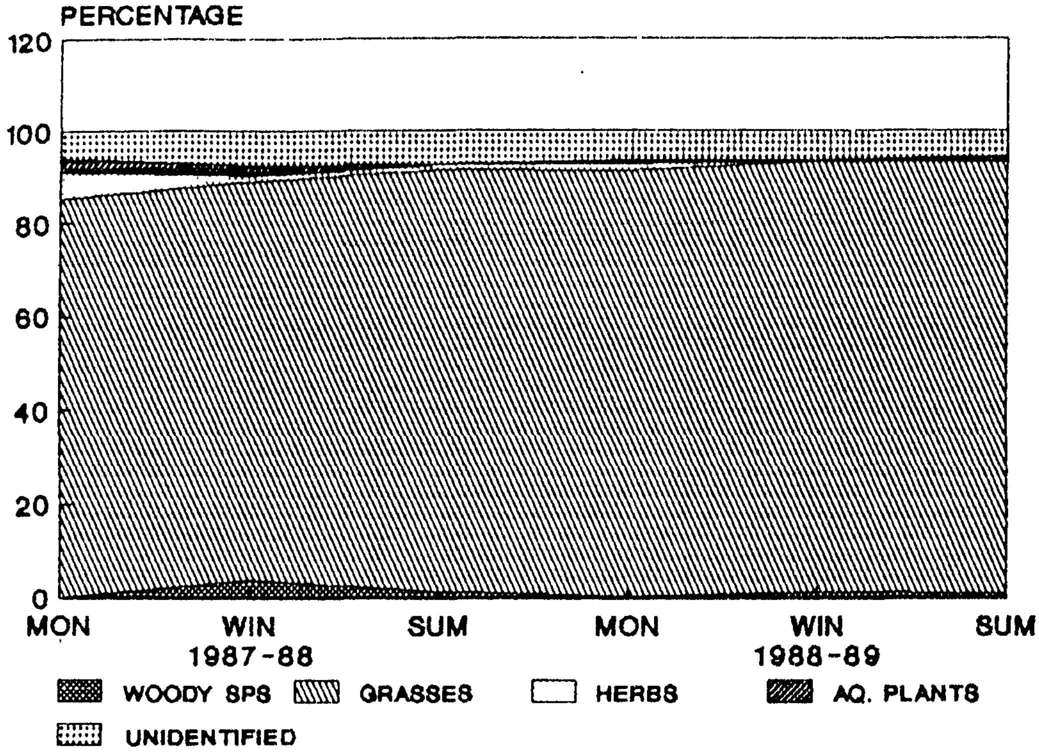
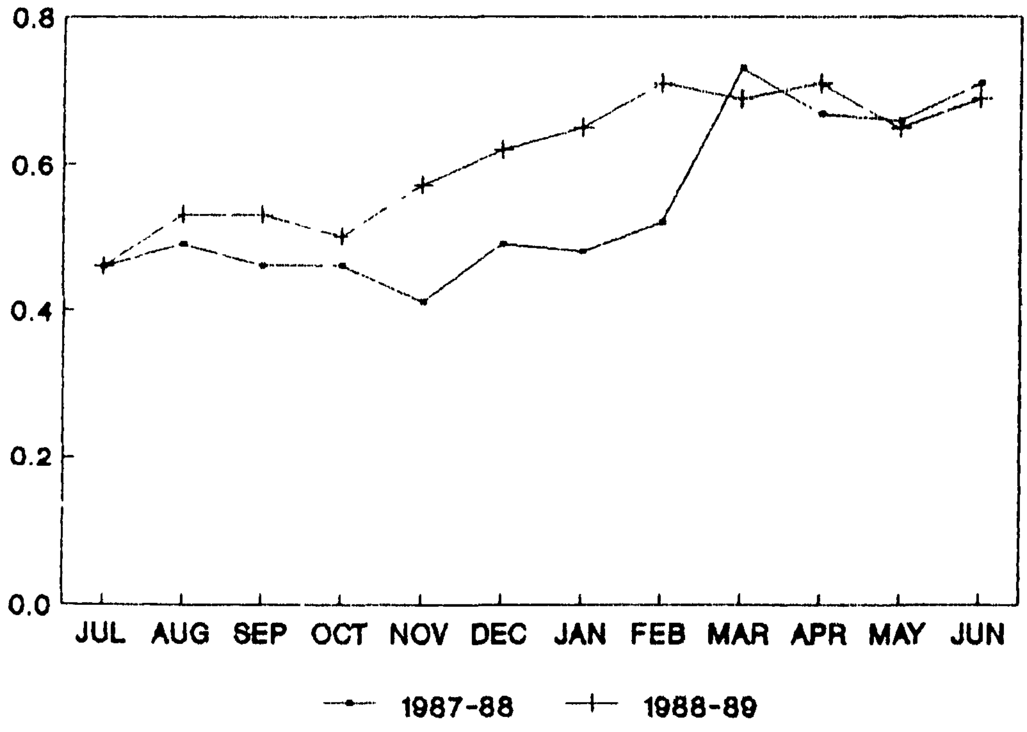


FIG 7.14

NICHE BREADTH OF FERAL CATTLE
BASED ON FOOD PLANTS



year it comprises five woody, 17 grass, seven herbs, and two aquatic macrophytes while in the latter year it comprises two woody, 15 grass, three herbs and one aquatic macrophyte.

Woody plants

Epidermal fragments of the woody plants in the faeces of Feral cattle were very few so data is too inadequate to show any seasonal trend.

Grasses

Epidermal fragments show that grasses were the staple food of the Feral Cattle. During 1987-88 it ranged from 85-90% while during 1988-89 it did not differ much among the season. It varied from 91 to 92% (Fig 7.13). Equally large proportion of grass fragments were found in the samples of all seasons.

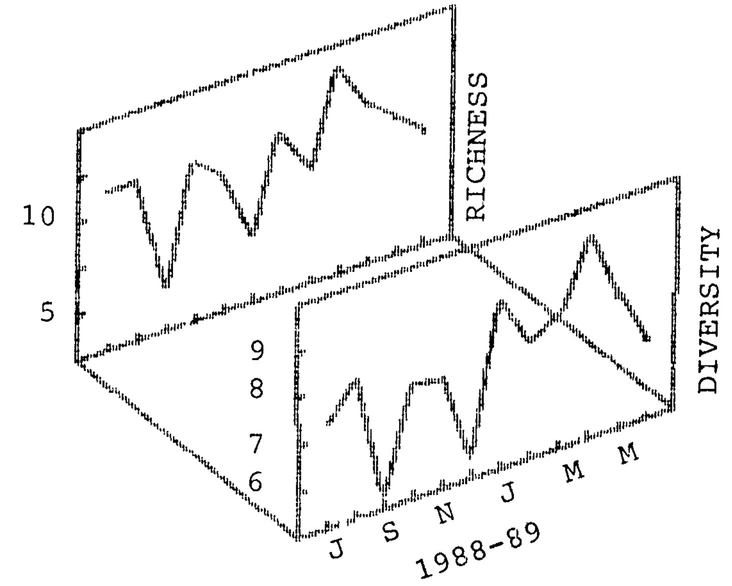
The most preferred food of Feral cattle was *Cynodon dactylon*, *Sporobolus* sp., *Paspalum distichum*, *Desmostachya bipinnata*, *Dicanthium annulatum* and *Vetiveria zizanioides*.

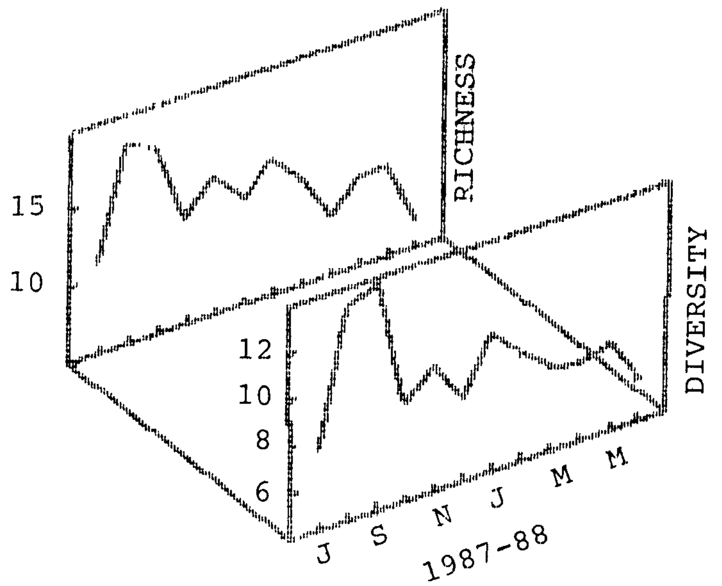
Herbs

Herbs' parts were negligible in the dung of Feral cattle (1-6%). In both the years the highest number of herb fragment were seen in the monsoon samples.

FIG 7.15

DIET RICHNESS AND DIVERSITY OF FERAL CATTLE





Aquatic macrophytes

Proportion of aquatic macrophyte fragments was insignificant in the dung of feral cattle. Very few animals were seen feeding in the aquatic area mostly on the grasses when the area got dried up.

Niche breadth

The niche breadth based on food items of feral cattle varied significantly ($P < 0.05$) between the two years. During 1987-89 the niche breadth varied from 0.41 in November to 0.73 in March while during 1988-89 it ranged from 0.46 in July to 0.71 in February (Fig 7.14).

Food diversity

The food diversity of feral cattle was significantly ($P < 0.05$) different between the two years. During the year 1987-88 the food diversity ranged from 5.87 in June to 13.76 in September (Fig 7.15). These values are apparently related to the availability of food plants. When during summer as amphibious grass like *Cyperus* sp. and *Scirpus* sp. , besides herbs are less abundant so feral cattle feed exclusively on terrestrial grass species like *Cynodon dactylon*, *Desmostachya bipinnata* and *Sporobolus* sp. besides *Paspalum distichum*. During 1988-89 the food diversity ranged from 5.29 in September to 9.38 in April. The diversity in 1988 was low in September and not in June as was the case in 1987 because in this particular month one species (*Dicanthium annulatum*) was dominant in the dropping of Feral cattle.

WILD BOAR

During 1987-88 fragments of 23 plant species were identified in the droppings of Wild boar of which two were of browse species, 13 of grasses, three of herbs, three of aquatic macrophytes and two of agricultural crops. In the samples of 1988-89, altogether 20 species were recorded of which two were browse, 12 of grasses, two of aquatic macrophytes and four ot agricultural crops (Appendix VI). The food of wild boar between the years did not show any variation.

Woody plants

Dropping analysis indicates that Wild boar did not show much of a preference to woody plants as of this species was only 5% to 8%. Most of which was composed of pods of *Prosopis juliflora*. In the year 1987-88 no fragments of woody plants were recorded during the monsoon.

Grasses

The proportion of grasses in the droppings of wild boar varied from 74% to 85% (Fig 7.16). Throughout both the years the proportion of grass species in the droppings did not vary much. During 1987-88 the most preferred food of Wild boar appeared to be *Cyperus rotundus*, followed by *Scirpus tuberosus* and *Cyperus alopecuroides* while during 1988-89 it was *Cyperus rotundus* followed by *Cyperus alopecuroides* and *Scirpus tuberosus*. During the latter year *Cyperus alopecuroides* was abundant and most of the aquatic area were covered by this species.

FIG 7.16

FOOD PREFERENCE OF WILD BOAR

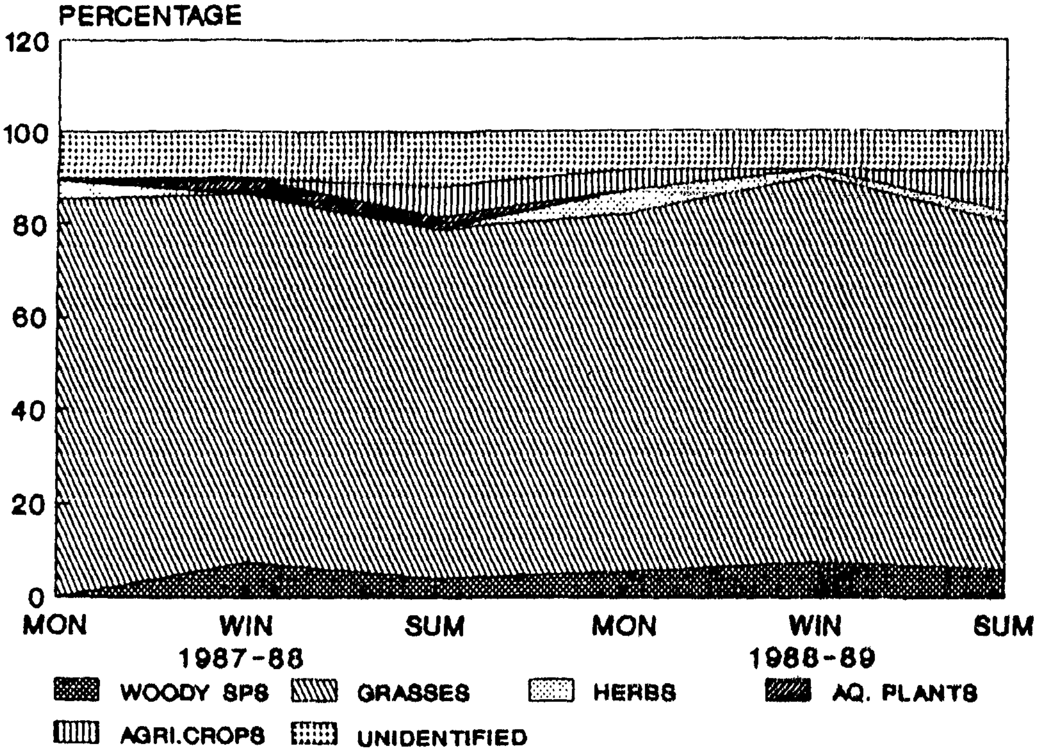
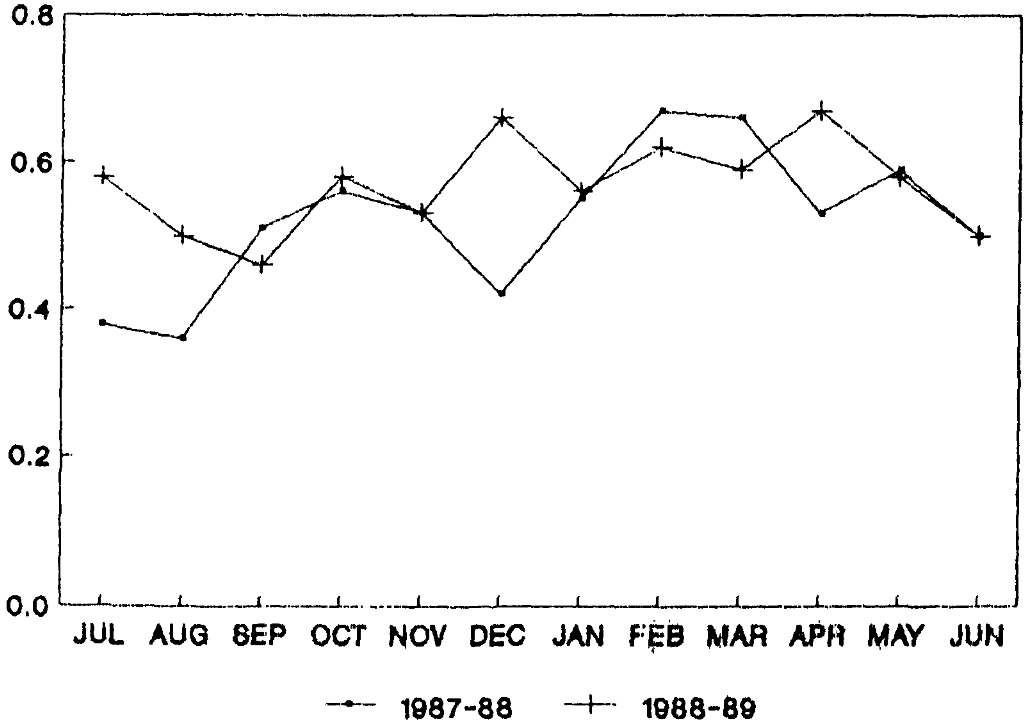


FIG 7.17

NICHE BREADTH OF WILD BOAR BASED ON FOOD PLANTS



Herbs

Herbs fragments were rarely found in the droppings of Wild boar. Only in the samples of the monsoon season of 1987-88 did some epidermal fragments occurred in the faeces of wild boar.

Aquatic macrophytes

Parts of aquatic macrophytes were also rare in the droppings of Wild boar, only 1% to 5% was noticed. In 1987-88 the maximum was in winter, whereas in 1988-89 it was during monsoon . Parts of *Ipomoea aquatica* and *Eleocharis* sp. were proportionately in large numbers compared to those of other macrophytes.

Agricultural crops

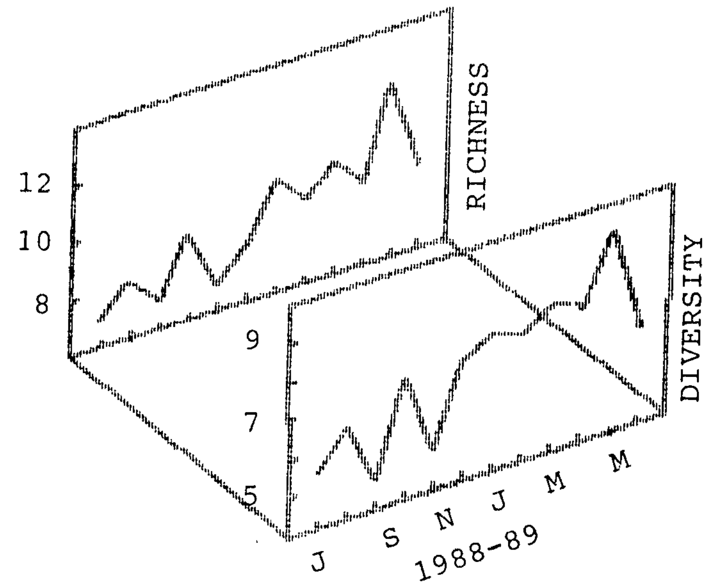
The proportion of epidermal fragments of agricultural crops in the dropping of wild boar ranged only from 4% to 8%. The samples collected during 1987-88 summer contained fragments of *Cicer arietinum* (Chana) and *Triticum aestivum* (Wheat), but the samples collected during monsoon and winter of that year had no fragments of any agricultural crop. However, the samples collected during monsoon of 1988-89 contained fragments of *Sorghum vulgare* (Jowar) and *Cicer arietinum* (Chana).

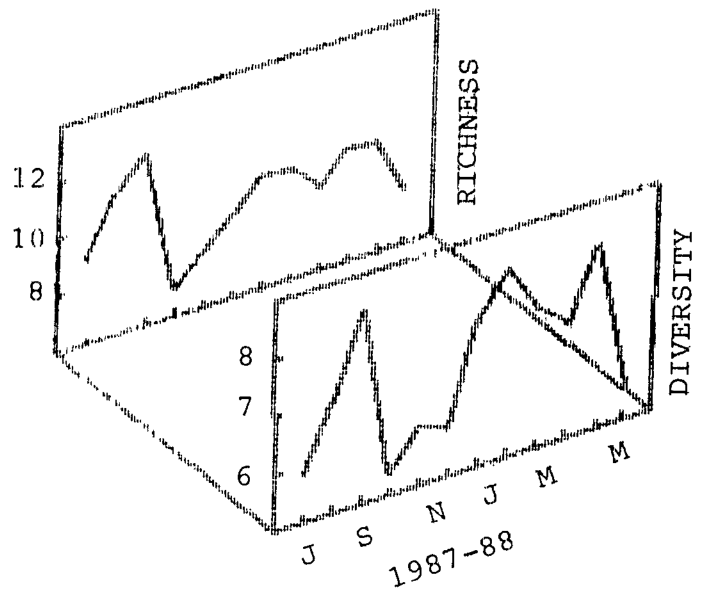
Niche breadth

The niche breadth of wild boar based on food varied ($P < 0.05$) significantly between the two years. During 1987-88 it ranged from 0.36 in August to 0.67 in February while during

FIG 7.18

DIET RICHNESS AND DIVERSITY OF WILD BOAR





1988-89 it varied from 0.46 in September to 0.67 in April (Fig 7.17). The difference in the niche breadth between the two years was due to the lack of food varieties caused by drought.

Food diversity

The food diversity did not differ much between the two years. In the year 1987-88 it ranged from 5.63 in June to 4.8 in September, whereas in the year 1988-89 it varied from 8.32 in September to 9.28 in May (Fig 7.18).

7.3.3 Browse productivity

The maximum mean dry weight per twig was of *Salvadora persica* (2.0235 gm) and minimum of *Capparis decidua* (0.5183 gm). The weight of former species was more due to the presence of broader and thicker leaves while in the case of the latter species no leaves are present on the twig only its stem were considered as the browse.

The density of each browse species calculated from the study plot was used to extrapolate the density for the whole sanctuary. The highest density recorded was of *Acacia nilotica* (61 /hectare) (Table 7.3); followed by *Prosopis juliflora* (54 /hectare) *Capparis decidua* had the lowest density (4 /hectare).

The total browse productivity of six major species was around 29.93 gm/m^2 of which *Prosopis juliflora* constituted the highest productivity (9.372 gm/m^2); followed by *Acacia nilotica* (8.947 gm/m^2). The least production was in *Capparis decidua*

Table 7.3

Browse productivity and utilization of major browse species

	Mean dry Wt per twig in gms	Density per hectare	SE of mean	Dry Wt of browse in gm/m^2	Wt consumed gm/m^2	Browse consumed in percentage
Capparis sepiaria	1.6835	38	0.041	4.734	0.8467	17.8
Capparis decidua	0.5183	4	0.015	0.126	0.0087	6.9
Balanites roxburghii	1.433	5	0.044	0.394	0.0336	8.52
Prosopis juliflora	1.827	54	0.056	9.372	0.3776	4.02
Salvadora persica	2.0235	26	0.059	6.365	0.2117	3.32
Acacia nilotica	1.93	61	0.071	8.947	1.0536	11.77

Table 7.4

Proportion (in gms) of each plant consumed by different ungulates

	Chital	Sambar	Nilgai	Feral cattle
Capparis sepiaria	0.1301	0.0498	0.5197	0.1469
Capparis decidua	0.0017	0.00012	0.0068	-
Balanites roxburghii	0.00185	-	0.02422	0.00749
Prosopis juliflora	0.04117	0.00386	0.29686	0.00749
Salvadora persica	0.0088	-	0.01378	0.1840
Acacia nilotica	0.102	0.0683	0.7576	0.1246

($0.126\ gm/m^2$). The reason for the highest productivity in *Prosopis juliflora*, (though its density and mean dry weight per twigs were less than those of *Acacia nilotica*) is the higher mean number of twigs growing on each bush. *Acacia nilotica* though larger in size, the productivity was accounted only below 2.5 m as the ungulates of the park could not reach above that.

Very few studies have been done on the primary productivity of browse species. Belovsky *et al.* (1973) found browse productivity at Isle Royale to be 36 gm dry weight/m^2 below 2.8 m. Grigal and Moody (1980) in Minnesota found 952 kg/hectare of browse productivity in his study. In India, Berwick (1974) found 34 gm dry wt/m^2 of productivity of shrub at Gir forest.

7.3.4 Browse utilization

Capparis sepiaria was the most browsed (17.8%) although its productivity was fourth in the rank. *Salvadora persica* which is third in order of productivity rank was least browsed (3.32%) (Table 7.3). Although *Prosopis juliflora* exceeds all the species in productivity, in the preference for utilization it was fifth (4.02%) in the order of preference.

The weight in gm/m^2 consumed of each plant species pertains to the feeding by all the ungulate species but it does not indicate how much each species has consumed. The consumption by each ungulate species was however estimated taking into consideration also the consumers' body weight and the fragments of plant species found in its droppings. Only the adult animals were taken into consideration. The forage intake was considered as 3% of animal body wt (Havstad et al 1983). The formula used is as follows:

$$W = \frac{W_f \times X_i}{\Sigma X_i}$$

Where W = Proportion of W_f consumed by animal i

W_f = Total forage consumed $/m^2$

$X_i = D \times W_a \times P_w \times P_{fi}$.

Where D = Population density of the species

W_a = Average body wt of the species

P_{wi} = Proportion of food intake to body wt

P_{fi} = Proportion of plant species i in the food.

Of all animal species Nilgais' rate of consumption appears to be highest for browse species. Feral cattle (although does not prefer browse species) comes second in the order of consumption rate probably because its body weight is the highest among all the ungulates. Chital although smaller than sambar, consume more browse than do other species (Table 7.4).

7.3.5 Chemical composition of plants

Changes in nutritional values of forage plants effects upon the condition and productivity of herbivores (Berwick 1974). Chemical composition of the major plants species was studied to know whether the nutritive value has any relation to the preference by different ungulates.

Protein

Dietary protein may influence the reproductive status of tropical animals (Sadleir 1969). Results of protein analysis are presented in Table 7.5. In all the ten major grass species, the highest protein level was recorded during winter season. It ranged from 8.07% in *Desmostachya bipinnata* to 23% in *Cynodon dactylon*. The lowest protein level was recorded during the summer. It varied from 9.7% in *Sporobolus* sp. to 15.53% in *Scirpus tuberosus*. During monsoon it ranged from 12.2% in *Cyperus rotundus* to 20.80% in *Dicanthium annulatum*. The seasonal variation in the protein content was noticed mainly in *Cynodon dactylon* ,*Desmostachya bipinnata*, *Paspalum distichum* and *Sporobolus* sp. while the other species did not show much variation (Table 7.5).

There was not much seasonal variation in the protein levels of browse species except in *Acacia nilotica* and *Capparis sepiaria* which had a high level during winter than in other seasons. In the case of *Balanites roxburghii* protein level was recorded maximum (17.22%) during summer. On an average, *Capparis sepiaria* had a high level of protein (18.03%) among the browse

Table 7.5

Protien content of major food species of ungulates

Species	*Monsoon*	*Winter*	*Summer*	*Average*
Acacia nilotica	16.25	16.49	13.48	15.04
Acacia nilotica (Pod)	-	-	15.05	15.05
Acacia leucophloea	23.72	-	-	23.72
Balanites roxburghii	-	14.3	17.22	15.7
Capparis sepiaria	16.01	21.24	16.85	18.03
Clerodendron phlomides	21.91	-	-	21.91
Dichrostachys cinerea	15.29	-	-	15.29
Kirgenelia reticulata	14.21	20.95	10.11	15.09
Prosopis juliflora	-	10.59	20.83	15.7
Prosopis spicigera	19.14	-	-	19.14
Salvadora oleoides	13.72	-	-	13.72
Salvadora persica	19.07	16.32	6.05	13.81
Salvadora persica (Fruit)	15.77	-	-	15.77
Zizyphus mauritiana	-	19.02	19.02	19.02
Bracharia reptans	7.72	-	-	7.72
Cynodon dactylon	19.51	23.1	15.05	19.22
Cyperus alopecuroides	-	22.15	12.64	11.59
Cyperus alopecuroides (INF)	-	10.11	11.08	10.6
Cyperus rotundus	12.2	-	-	12.2
Desmostachya bipinnata	12.42	8.07	14.93	11.8
Dicanthium annulatum	20.80	15.85	17.34	17.99
Echinocloa colonum	12.52	29.74	12.52	14.92
Echinocloa (INF)	26.49	-	-	26.49
Eragrostis spp.	25.28	-	-	25.28
Eriochloa procera	12.4	-	-	12.4
Iseilema laxum	16.97	-	-	16.97
Paspalum distichum	15.57	15.89	9.63	13.6
Paspaldium spp.	-	21.29	20.11	20.7
Pseudorophis spinescens	-	26.25	14.05	20.15
Prosopis juliflora (Fruit)	-	-	14.09	14.09
Setaria spp.	19.50	-	-	19.5
Scirpus tuberosus	16.85	15.05	15.53	15.81
Sporobolus helvolus	-	20.83	9.75	15.29
Vetiveria zizanioides	13.80	15.85	14.45	14.7
Oryza sativa	14.80	-	-	14.8
Achyranthes aspera	12.09	-	-	12.09
Calotropis procera	4.33	-	-	4.33
Commelina forskalli	21.07	-	-	21.07
Dregia spp.	9.39	-	-	9.39
Ipomoea aquatica	-	-	10.23	10.23
Merremia emerginata	19.08	-	-	19.08
Trianthema portulacastrum	21.79	-	-	21.79
Eleocharis plantaginea	22.87	-	-	22.87
Hydrilla verticillata	18.54	-	-	18.54
Panicum antidotale	22.15	-	-	22.15
Pennisetum typhoides (Bazra)	9.75	-	-	9.75
Sorghum vulgare (Jawar)	9.87	-	-	9.87
Cicer arietinum (Chana)	19.38	-	-	19.38
Pisum sativum (Matar)	16.97	-	-	16.97
Brassica campestris (Mustard)	15.89	-	-	15.89
Triticum aestivum (Wheat)	25.04	-	-	25.04
Desmostachya bipinnata (After				20.55
Vetiveria zizanioides burnt)				26.00

INF = Inflorescence   Note : Values are in percentage

Table 7.6

Significance test of correlation between different nutritive value and food preference

	PROT	CAL	EX	FOOD
PROT				
CAL	-			
EX	-	+		
FOOD	+	-	+	

Chital

	PROT	CAL	EX	FOOD
PROT				
CAL	-			
EX	-	+		
FOOD	-	-	-	

Nilgai

	PROT	CAL	EX	FOOD
PROT				
CAL	-			
EX	-	+		
FOOD	-	-	-	

Sambar

	PROT	CAL	EX	FOOD
PROT				
CAL	-			
EX	-	+		
FOOD	-	-	-	

Feral cattle

	PROT	CAL	EX	FOOD
PROT				
CAL	-			
EX	-	+		
FOOD	+	-	-	

Blackbuck

	PROT	CAL	EX	FOOD
PROT				
CAL	-			
EX	-	+		
FOOD	-	-	-	

Wild boar

+ = Significant at level P = 0.05.
- = Not significant
PROT = Protein, CAL = Calorific, EX = Ether extract

species. Protein showed a positively significant correlation with the food of Chital and Blackbuck while it did not show such correlation with the diet of other ungulates (Table 7.6).

Calorific value

Most of the major grass species had a high calorific value during winter ranging from 3.46% in *Desmostachya bipinnata* to 6.86% in *Paspalum distichum*. Most grass species had the lowest calorific value was in summer; It varied from 2.18% in *Desmostachya bipinnata* to 5.16% in *Paspalum distichum*. In the case of *Dicanthium annulatum* the highest calorific value was during monsoon and summer (4.3%). *Vetiveria zizanioides* also had higher value during monsoon (5.58%) (Table 7.7).

Of all the major browse species, the maximum calorific value was recorded during winter. It ranged from 5.58% in *Balanites roxburghii* to 7.7% in *Acacia nilotica*, whereas the lowest values were obtained during summer which varied from 3.02% in *Balanites roxburghii* to 6.41% in *Acacia nilotica*. The seasonal variation was noticed only in *Capparis sepiaria* and *Balanites roxburghii*, whereas *Acacia nilotica* did not show any seasonal variation. There seem a negative correlation between the calorific value and the ether extract values of all the food plants (Table 7.6).

Ether extract

The ether extract value for most of the grass species were recorded maximum during summer. It ranged from 2.4% in *Sporobolus*

Table 7.7

Calorific value of major food species of ungulates

Species	Monsoon	Winter	Summer	Average
Acacia nilotica	7.28	7.7	6.41	7.13
Acacia nilotica (Pod)	-	-	5.16	5.16
Acacia leucophloea	5.48	-	-	5.48
Balanites roxburghii	-	5.58	3.02	4.3
Capparis sepiaria	6.4	6.86	4.74	6.0
Clerodendron phlomides	3.8	-	-	3.8
Dichrostachys cinerea	5.48	-	-	5.48
Kirgenelia reticulata	5.4	5.16	3.2	4.58
Prosopis juliflora	-	4.3	3.46	3.88
Prosopis spicigera	5.48	-	-	5.48
Salvadora oleoides	3.48	-	-	3.48
Salvadora persica	4.3	4.74	2.6	3.88
Salvadora persica (Fruit)	6.44	-	-	6.44
Zizyphus mauritiana	-	1.762	3.02	2.39
Bracharia reptans	4.36	-	-	4.36
Cynodon dactylon	6.16	6.44	4.74	5.78
Cyperus alopecuroides	-	6.16	3.3	4.73
Cyperus alopecuroides (INF)	-	3.46	1.76	2.61
Cyperus rotundus	5.58	-	-	5.58
Desmostachya bipinnata	2.61	3.46	2.18	2.77
Dicanthium annulatum	4.3	3.88	4.3	4.16
Echinocloa colonum	7.8	5.58	4.74	6.04
Echinocloa (INF)	4.36	-	-	4.36
Eragrostis spp.	6.64	-	-	6.64
Eriochloa procera	7.2	-	-	7.2
Iseilema laxum	5.48	-	-	5.48
Paspalum distichum	6.16	6.86	5.16	6.06
Paspaldium spp.	-	2.6	2.6	2.6
Pseudorophis spinescens	-	5.58	5.16	5.37
Prosopis juliflora (Fruit)	-	-	4.3	4.3
Setaria spp.	5.16	-	-	5.16
Scirpus tuberosus	5.58	6.16	4.74	5.01
Sporobolus helvolus	-	5.58	4.74	5.16
Vetiveria zizanioides	5.58	3.88	2.6	4.08
Oryza sativa	6.16	-	-	6.16
Achyranthes aspera	2.6	-	-	2.6
Calotropis procera	4.3	-	-	4.3
Commelina forskalli	5.48	-	-	5.48
Dregia spp.	6.44	-	-	6.44
Ipomoea aquatica	-	-	2.6	2.6
Merremia emerginata	5.48	-	-	5.48
Trianthema portulacastrum	4.48	-	-	4.48
Eleocharis plantaginea	5.48	-	-	5.48
Hydrilla verticillata	6.64	-	-	6.64
Panicum antidotale	6.64	-	-	6.64
Pennisetum typhoides (Bazra)	3.52	-	-	3.52
Sorghum vulgare (Jawar)	2.67	-	-	2.67
Cicer arietinum (Chana)	4.37	-	-	4.37
Pisum sativum (Matar)	3.52	-	-	3.52
Brassica campestris (Mustard)	2.67	-	-	2.67
Triticum aestivum (Wheat)	6.07	-	-	6.07
Desmostachya bipinnata (After				4.31
Vetiveria zizanioides burnt)				4.31

INF = Inflorescence Note : Values are in percentage

Table 7.8

Ether extract of major food species of ungulates

Species	Monsoon	Winter	Summer	Average
Acacia nilotica	4.8	3.8	4	4.2
Acacia nilotica (Pod)	-	-	5.0	5.0
Acacia leucophloea	3.4	-	-	3.4
Balanites roxburghii	-	4	4.2	4.1
Capparis sepiaria	1.8	4.4	5.0	3.73
Clerodendron phlomides	4.0	-	-	4.0
Dichrostachys cinerea	4.0	-	-	4.0
Kirgenelia reticulata	3.0	4.2	4.6	3.93
Prosopis juliflora	-	4	1.8	2.9
Prosopis spicigera	4.2	-	-	4.2
Salvadora oleoides	3.4	-	-	3.4
Salvadora persica	4	3.8	4.2	4.0
Salvadora persica (Fruit)	3.0	-	-	3.0
Zizyphus mauritiana	-	3.6	4.0	3.5
Bracharia reptans	3.8	-	-	3.8
Cynodon dactylon	2.6	3.0	3.6	3.6
Cyperus alopecuroides	-	6.0	4.2	5.1
Cyperus alopecuroides (INF)	-	4.2	4.0	4.1
Cyperus rotundus	2.0	-	-	2.0
Desmostachya bipinnata	5.0	4.0	3.8	4.26
Dicanthium annulatum	2.4	3.8	4.4	3.53
Echinocloa colonum	3.2	5.2	1.6	3.33
Echinocloa (INF)	3.6	-	-	3.36
Eragrostis spp	4.0	-	-	4.0
Eriochloa procera	5.0	-	-	5.0
Iseilema laxum	4.0	-	-	4.0
Paspalum distichum	2.0	3.8	3.8	3.2
Paspaldium spp	-	4.4	4.0	4.2
Pseudorophis spinescens	-	3.0	3.6	3.3
Prosopis juliflora (Fruit)	-	-	4.0	4.0
Setaria spp.	6.0	-	-	6.0
Scirpus tuberosus	3.2	2	3.6	2.93
Sporobolus helvolus	-	1.8	2.4	2.1
Vetiveria zizanioides	2.0	2.4	4.6	3.0
Oryza sativa	5.6	-	-	5.6
Achyranthes aspera	7.0	-	-	7.0
Calotropis procera	5.0	-	-	5.0
Commelina forskalli	3.6	-	-	3.6
Dregia spp.	5.0	-	-	5.0
Ipomoea aquatica	-	-	4.2	4.2
Merremia emerginata	2.2	-	-	2.2
Trianthema portulacastrum	4.8	-	-	4.8
Eleocharis plantaginea	3.2	-	-	3.2
Hydrilla verticillata	3.2	-	-	3.2
Panicum antidotale	3.2	-	-	3.2
Pennisetum typhoides (Bazra)	2.2	-	-	2.2
Sorghum vulgare (Jawar)	1.4	-	-	1.4
Cicer arietinum (Chana)	2.8	-	-	2.8
Pisum sativum (Matar)	3.2	-	-	3.2
Brassica campestris (Mustard)	4.8	-	-	4.8
Triticum aestivum (Wheat)	2.4	-	-	2.4
Desmostachya bipinnata (After				2.8
Vetiveria zizanioides burnt)				1.8

INF = Inflorescence   Note : Values are in percentage

sp. to 3.6 in *Cynodon dactylon*. The percentage of ether extract during monsoon was the lowest. It varied from 2% in *Vetiveria zizanioides* to 2.6% in *Cynodon dactylon*. *Desmostachya bipinnata* was the only species which showed the maximum (5%) value during the monsoon (Table 7.8).

Among the browse species the higher ether extract values were recorded in summer in *Capparis sepiaria* and *Balanites roxburghii* but *Acacia nilotica* showed higher value during monsoon (4.8%). A lower value was recorded during winter for the last two species, whereas the first species showed the lowest value during monsoon.

7.3.6 Correlation between food abundance and food preference

The correlation between the grass abundance (calculated in volume) and food preference in terms of frequency of plant fragments present in the dropping of each ungulate species showed insignificant correlation. Only Feral cattle showed the significant relation between the availability of grass species and food preference. (Table 7.9).

There is a significant correlation between the browse abundance (calculated in terms of density) and the food preference of major browsers (Nilgai, Chital and Sambar) (Table 7.10). This can be corroborated with the high density of browse species in the Park. It shows that the animal are not selective as regards ~~to the~~ browse.

Table 7.9

Correlation (r) between the availability of grasses and the preference for them by ungulates

Species	r
Sambar	-0.167
Blackbuck	0.013
Chital	0.052
Nilgai	0.231
Feral cattle	0.400
Wild boar	0.146

Table 7.10

Correlation (r) between the availibility of browse and the preference for them by ungulates

Species	r
Chital	.716
Sambar	0.640
Nilgai	0.702

7.3.7 Similarity in the food preference

Similarity in the seasonal preference for food by ungulates was worked out for both the years.

Similarity during monsoon

The food of Chital and of Blackbuck was more or less similar during monsoon of 1987-88 when both these species were seen feeding on *Cynodon dactylon* and *Sporobolus* spp. Feral cattle was also closer to both Chital and Blackbuck but not to the extent these two species were with each other (Fig 7.19).

The pattern changed during 1988-89 when Feral cattle and Blackbuck appeared to be closer to each other than was Chital with either of them. Similarity between food of Chital and Feral cattle was more than between Chital and Blackbuck (Fig 7.20).

In both the years, Nilgai formed closer guild with Blackbuck, Feral cattle and Chital. Sambar and Wild boar showed totally distinct guilds. The former being mostly using the aquatic plant and Wild boar mainly the sedges such as *Cyperus* spp. and *Scirpus* spp.

Similarity during winter

The pattern of similarity in the winter food of different species varied from 1987-88 to 1988-89. During 1987-88 the maximum similarity was between Blackbuck and Feral cattle when both these species were seen feeding on *Cynodon dactylon* and

FIG 7.19

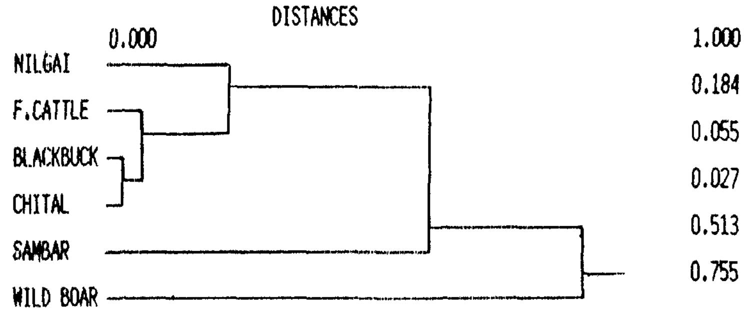
SIMILARITY IN THE FOOD PREFERENCE OF UNGULATES

DURING 1987-88

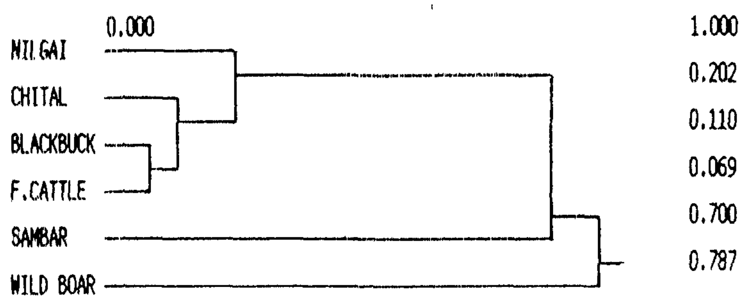
Distance metric is 1-Pearson Correlation Coefficient

Average linkage method

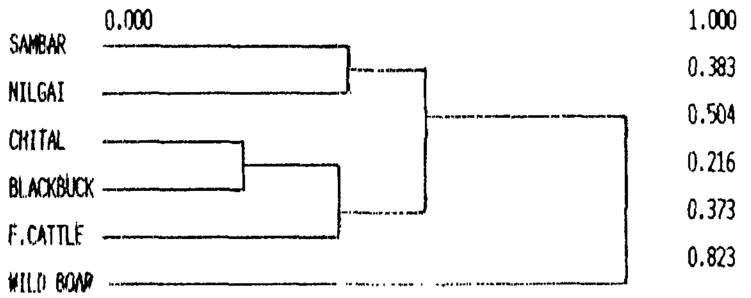
TREE DIAGRAM



MONSOON



WINTER



SUMMER

FIG 7.20

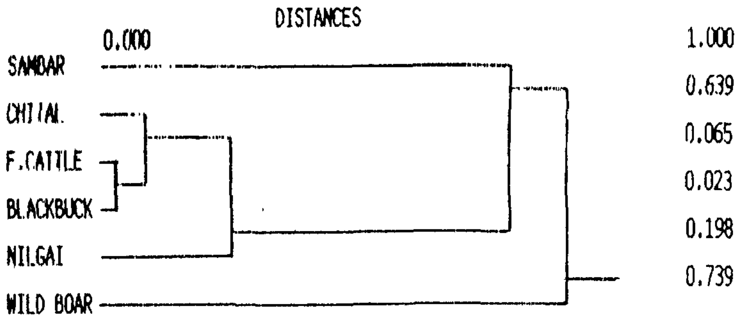
SIMILARITY IN THE FOOD PREFERENCE OF UNGULATES

DURING 1988-89

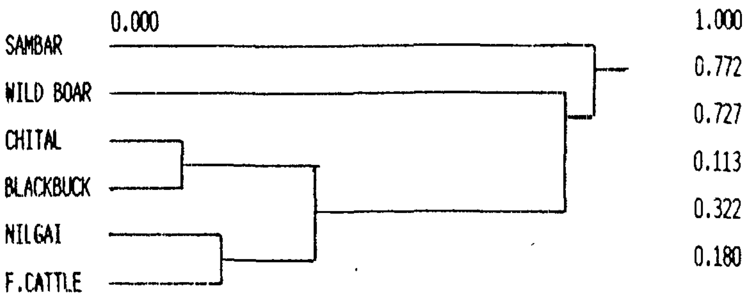
Distance metric is 1-Pearson Correlation Coefficient

Average linkage method

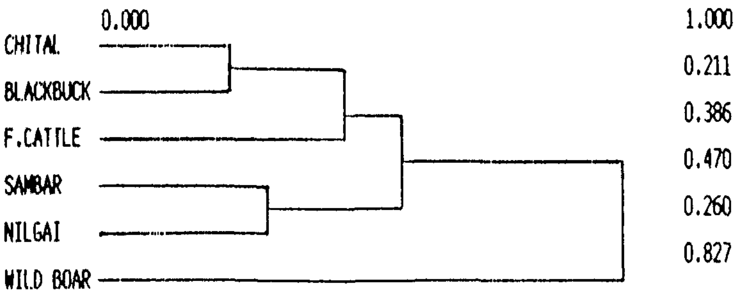
TREE DIAGRAM



MONSOON



WINTER



SUMMER

Sporobolus spp. (Fig 7.19). Chital was also closer to this guild but it was having had higher similarity with Blackbuck than with Feral cattle. This may be because of more fragments of *Eragrostis* spp. and *Sporobolus* spp. present in the dropping of Chital and Blackbuck than Feral cattle.

Nilgai was the next in order of close associat~~ed~~ion with the above three ungulates. On the other hand Sambar and Wild boar formed a separate guild, as in monsoon.

During winter of 1988-89 Chital showed similarity with Blackbuck (Fig 7.20). Nilgai and Feral cattle also showed significant similarity in their food preference when both these species were seen feeding on fresh sprout of *Desmostachya bipinnata* and *Vetiveria zizanioides* soon after the outbreak of fire in October 1988.

Similarity during summer

The similarity in the food preference by different ungulates during summer was not so distinct as was other seasons. In both the years the pattern of similarity was similar (Fig 7.19, 7.20). Chital and Blackbuck showed similarity in their food preference though it was comparatively less than the other seasons. Although some Chital went for browsing, a few were seen grazing on the same species on which Blackbuck had grazed. Sambar and Nilgai, which were mostly dependent upon ~~the~~ browse during summer formed a separate guild.

Table 7.11

Summary of food plant preferred by different ungulates

	Monsoon	Winter	Summer
Chital	*Cynodon dactylon* *Sporobolus* spp. *Echinocloa* spp. *Dicanthium annulatum*	*Cynodon dactylon* *Eragrostis* spp. *Sporobolus* spp. *Acacia nilotica* *Zizyphus mauritiana*	*Cynodon dactylon* *Sporobolus* spp. *Acacia nilotica* *Capparis sepiaria*
Sambar	*Paspalum distichum* *Sporobolus* spp. *Echinocloa* spp. *Ipomea aquatica* *Hydrilla* spp. *Acacia nilotica*	*Paspalum distichum* *Cyperus* spp. *Scirpus* spp. *Echinocloa* spp. *Acacia nilotica*	*Paspalum distichum* *Sporobolus* spp. *Acacia nilotica* *Capparis sepiaria*
Blackbuck	*Cynodon dactylon* *Sporobolus* spp. *Dicanthium annulatum*	*Cynodon dactylon* *Sporobolus* spp. *Dicanthium annulatum*	*Cynodon dactylon* *Sporobolus* spp. *Dicanthium annulatum* *Paspalum distichum*
Nilgai	*Cynodon dactylon* *Sporobolus* spp. *Paspalum distichum* *Scirpus* spp. *Acacia nilotica* *Balanites roxburhii* *Pennisetum typhoides* (Bazra)	*Cynodon dactylon* *Sporobolus* spp. *Paspalum distichum* *Acacia nilotica* *Brassica campestris* (Mustard)	*Paspalum distichum* *Desmostachya bipinnata* *Vetiveria zizanioides* *Acacia nilotica* *Capparis sepiaria* *Pisum sativum*(Matar) *Triticum aestivum*(Wheat)
Feral cattle	*Cynodon dactylon* *Sporobolus* spp. *Paspalum distichum*	*Cynodon dactylon* *Sporobolus* spp. *Dicanthium annulaum* *Desmostachya bipinnata*	*Cynodon dactylon* *Sporobolus* spp. *Paspalum distichum* *Desmostachya bipinnata* *Vetiveria zizanioides*
Wild boar	*Cyperus* spp. *Scirpus* spp. *Sorghum vulgare*(Jawar)	*Cyperus* spp. *Scirpus* spp. *Desmostachya bipinnata*	*Cyperus* spp. *Scirpus* spp. *Prosopis juliflora* *Triticum aestivum*(Wheat)

Feral cattle was closer to the guild of Chital and Blackbuck. They fed mostly on *Desmostachya bipinnata* and *Vetiveria zizanioides* which is not preferred by other ungulates. Wild boar formed a separate guild because of their preference for *Cyperus* spp., *Scirpus* spp.

7.4 Discussion

Analysis of dropping of all the ungulate species found in Keoladeo National Park has indicated that proportion of grasses in the diet of each is much higher than of other plant species. This finding is in agreement with those of Karfhage (1974), Vavra *et al.* (1978) and Michael *et al.* (1983). There can be various reasons for the higher occurrence of grass fragments in the droppings, which does not necessarily mean that that the diets of all the species mainly consists of grasses. There is a fair possibility that other plants or their specific parts eaten by ungulate get readily and completely digested and no recognizable fragments pass out in droppings (Crocker 1959, Johnson and Pearson 1981). Other reports, however, suggest that differential digestibility of plant species is not the reason for the occurrence in higher proportion of grass fragment in the droppings (Dearden *et al.* 1975). To resolve such likely confusion, digestibility coefficients of various plant species will have to be calculated, which could not be undertaken because of limitations i.e. lack of equipment and time.

The food preference of Chital as revealed by droppings' analysis indicates that the species is primarily a grazer but it resorts to browsing to make up for the shortage of grasses only during summer season. Similar conclusion had been drawn by Berwick (1974), Sharatchandra and Gadgil (1975) and Ables (1977). The same is the case of Sambar. It is primarily a grazer but browses in summer when it has to move towards the terrestrial area. In contrast to the other ungulates of the Park, terrestrial habitats were practically not used by Sambar for grazing, except in summer. Most of the time Sambar were seen feeding on grasses such as *Paspalum distichum* and *Cyperus* spp. and wading in the water to feed on aquatic macrophytes like *Ipomoea aquatica*, *Hydrilla* sp. which grow below the surface. Few Sambar were also seen browsing on leaves of *Acacia nilotica* planted on the mounds. Martin (1977) found Barasingha *Cervus duvauceli branderi* feeding mainly in the aquatic area.

Blackbuck and Feral cattle almost totally depend on grazing though in few instances Feral cattle were seen browsing on the leaves of *Salvadora persica* and *Acacia* spp. Wild boar on the other hand, subsists on the tubers of *Cyperus* spp. and *Scirpus* spp. (Table 7.11) which are dug out and eaten.

Blackbuck and Feral cattle are the only species at Keoladeo National Park which feed in large quantity on dry *Cynodon dactylon* and *Desmostachya bipinnata* during summer. Similar observation was reported by Ghosh and Goyal (1983) and Goyal *et al.* (1986) working on Blackbuck at Jodhpur.

Nilgai is the only species in Keoladeo National Park which browses throughout the year. Berwick (1974) also reported the same phenomenon from Gir forest. However, Sheffield *et al.* (1983)

reported moderate browsing by Nilgai in Texas. An interesting observation has been made on the feeding habit of Blackbuck and Nilgai in Keoladeo National Park. These two species were seen browsing on highly laticiferous leaves of *Calotropis* which is poisonous to man. These leaves are, however, rich in calcium and this may be the reason for consumption. Sharatchandra and Gadgil (1975) also reported that *Calotropis* was browsed by Chital. Rahmani (pers. comm.) also reported that *Calotropis* was browsed by Chinkara *Gazella bennettii*.

On the basis of their feeding habits the ungulates of Keoladeo National Park can be divided into four groups, as follows:

(a) Totally dependent on grazing e.g. Blackbuck and Feral cattle
(b) Dependent on grazing as long as grasses are available but switch over to browsing when grasses are scarce e.g. Chital and Sambar
(c) Mixed feeders, grazing as well as browsing e.g. Nilgai
(d) Dependent on underground tubers and roots e.g. Wild boar

Niche breadth

The niche breadth of all the ungulates varied from season to season, the narrowest breadth being during the monsoon and winter when food was abundant. During the dry season, when there was scarcity of grasses, (when the mean volume (in M^3) of palatable species per plot of 200 m^2 was 21.9 m^3) most of them subsist on whatever food is available, such as *Cynodon dactylon* ,*Sporobolus* sp. *Paspalum distichum* irrespective of their preference.

During monsoon and winter when vegetation grows in abundance, (when the mean volume (in m^3) of palatable species per plot of 200 m^2 was 42.4 m^3 and 40.6 m^3 respectively) (Table 3), they get the freedom to eat their most preferred foods and hence the niche breadth gets restricted. On a comparative basis, Feral cattle has the maximum niche breadth.

The species with a broader niche are called a generalists while those with a narrow niche are called specialists (Mac Arthur 1958, MacArthur and Levins 1967, Cody 1974, Pianka 1978). According to optimal foraging theory when resource availability is more, niche breadth will be minimum (Emlen 1966, MacArthur and Pianka 1966, MacArthur 1972, Charnov 1976).

A consumer can not afford to be discriminate and choosy when food resources are scarce, because considerable time and energy is lost in search of preferred food which is widely scattered. In such condition, a broader niche maximizes return per unit energy expenditure. The animal under such circumstances will tend to be a generalist, while rich food supplies lead to selective foraging and narrower niche breadth.

The reason of cattle being generalist are explained by Dudzinski and Arnold (1973), Grant *et al.* (1985). According to them cattle have a large voluminous ruminoreticulum to cater to their comparatively bulky bodies, and hence consume large quantities of food each day. The other possible reason of cattle at Bharatpur being generalist can be traced in their ancestry. They are the descendent of domesticated animals who were adapted to live on all sorts of food including straw supplied by their owners. Thus they have wider niche.

Their choice of a vegetation community on which to feed is related to the abundance and availability of plant material within it and, it is likely that cattle will not select a community with a lower threshold value of abundance because their high intake requirements will not be met by smaller bites in relation to their metabolic requirements (Illius and Gorden 1987).

During summer when most of the grasses get dried up the Feral cattle fed mainly on the *Desmostachya bipinnata* and *Vetiveria zizanioides* besides other species of grasses which constitute the highest biomass . Gorden (1989) also reported that cattle in winter, selectively fed on communities that had the highest biomass, when the live biomass of graminoids in the mesotrophic grasslands was low.

Nutrient value of plants

It is generally known that the grasses with less than 4% crude protein content are inadequate for ruminants to maintain their body weight (Milford and Minson 1966, Breden *et al.* 1963). Milford and Minson (1966) and French (1957) reported that ruminal activity is depressed when the diet contains less than 7% crude protein and digestibility decreases if crude protein content in food is below 3%.

The protein content level of most of the grass species in Keoladeo National Park is high. This finding may be due to the fact that different methods have been adapted by the author of this report and by others to calculate the protein content.

Usually protein level is calculated by estimating the Nitrogen content and then multiplying it by the factor 6.25. But in the present study the protein was estimated directly (Oser 1979). The supply of nitrates in Keoladeo National Park by the excretions of a very large number of birds and also mammals particularly Feral cattle may be a cause of higher protein content of vegetation. Browse species are richer in protein than grasses and also have higher calorific value. Field (1976) working on Buffaloes in Uganda found that crude protein levels of browse species is 3-4 times that of grass species. Similar observation was made in Kenya by Field and Blankenship (1973); protein level in their study ranged from 11.1% in *Acacia* sp. green pods to 38.4% in *Capparis* sp. Pellow (1984) in his study also found that all the browse species have a high protein value.

Food preference of ungulates at Bharatpur does not seem to be influenced by the protein and calorific value of vegetation except Chital and Blackbuck which showed a correlation with the protein content (Table 7.6). Field (1976) also holds that a direct relationship between the concentration of a factor and food preference is rarely found. Usually there is an interplay between attractants and repellants with availability as an over riding factor. With abundant food the animal probably experiences this interplay in the vegetation from which it has to choose. According to Pellow (1984) when neither nutritional quality nor digestibility are limiting factors as in the case of diet in wet seasons, palatability may become the dominant selection criterion, and hence, the animals choose the most palatable of the nutritionally rich foods.

Diet similarity

The overall conclusion is that Chital, Blackbuck and Feral cattle have some dietary overlap among them during monsoon and winter seasons. The dietary overlap during monsoon and winter seasons does not seem to have any adverse affect on any species as there is hardly any competition of food during this period abundance. According to Nanjappa (pers. comm.) the standing biomass of the park during monsoon and winter on an average is 400 gm/m^2.

Cattle, because of the structure of their lower jaw cannot feed on grasses flushed to the ground closer than 12 mm to the surface (Leigh 1974) but are able to feed on tall grasses such as *Desmostachya bipinnata* and *Vetiveria zizanioides* on which no other ungulate feeds. This phenomenon helps in avoidance of competition during periods of food scarcity. But many other factors may be operating in the Park and in order to reveal other such factors more intensive studies are called for. There is a possibility of competition for food between different species under compelling circumstances during the period of scarcity. If that happens, it will be detrimental to one or more species. Advance management steps are recommended to regularly monitor the situation and to prevent the onset of competition and niche overlap particularly during the scarcity of food resources.

7.5 Summary

1) The food habits showed that Blackbuck and Feral cattle are primarily grazer while Sambar and Chital are grazer in monsoon and winter but becomes browser during summer. Nilgai are mixed feeders, grazing as well browsing. Wild boar on the other hand, depend on tubers and roots.

2) Chital mainly prefer *Cynodon dactylon* and *Sporobolus* sp. among the grass species while *Acacia nilotica* and *Capparis sepiaria* were preferred among browse species.

3) *Paspalum distichum*, *Acacia nilotica* and *Ipomoea aquatica* forms the major food of Sambar.

4) Blackbuck preferred *Cynodon dactylon*, *Dicanthium annulatum* and *Sporobolus* spp.

5) Nilgai feed mainly on *Cynodon dactylon*, *Sporobolus* spp., *Scirpus* spp. and *Paspalum distichum* among the grass species whereas, *Acacia nilotica*, *Capparis sepiaria* and *Balanites roxburghii* are major browse species.

6) Feral cattle preferred *Cynodon dactylon*, *Sporobolus* spp., *Paspalum distichum*, *Desmostachya bipinnata* and *Vetiveria zizanioides*.

7) Sedges such as *Cyperus* spp., and *Scirpus* spp. are the preferred food of Wild boar.

8) There is insignificant correlation between the grass abundance (calculated in terms of volume) and food preference of ungulates, except in the case of Feral cattle, whence it is significant.

9) There appears correlation between the browse abundance and food preference by browsers (Nilgai, Chital and Sambar).

10) The niche breadth of food of all the ungulates was found to vary from season to season. The narrowest breadth were seen during the monsoon and winter seasons when food becomes abundant.

11) The nutritive value of major food species does not seem to have any relationship with the food preference except in the case of Chital and Blackbuck who appears to relish rich proteinous food.

12) The overall result of the diet similarity among all the ungulates reveals that Chital, Blackbuck and Feral cattle have some diet overlap during different seasons, least during the summer.

8. IMPACT OF GRAZING ON VEGETATION

8.1 Introduction

There is a growing awareness of the need to formulate grazing strategies which would allow maximum herbage utilization without deterioration of the land particularly in the tropical countries having successional grasslands subjected to immense grazing pressure from large cattle population (Swartzman and Singh 1974).

Studies on various ecological aspects of ungulates in the sub-continent have been done by Schaller (1967), Berwick (1974), Mishra (1982), Rice (1984) and Green (1988). But the grazing impact of ungulates on the ecosystem has not so far been quantified. Keoladeo National Park has been supporting, for many years, a large population of Feral cattle and thus it is a good site for such studies. The present study on vegetation dynamics and grazing pressure was, therefore, taken up.

The negative role of Feral cattle in the park ecosystem is significant. Their feeding behaviour, unlike of that other species of ungulates, causes damage to vegetation, alters the vegetation community composition and deprives other animal species of their legitimate share of food resources. Apart from these, Feral cattle also trample ground vegetation by their wide hoofs.

8.2 Methodology

Grids of 400 m x 400 m covering the entire Park were laid and 150 intersection of the transects covering all the habitats were selected for intensive study. Data was collected in circular sample plots of 8 m radius with a centre on each intersection.

1) Total grass cover
2) Average height and percentage of each plant species
3) Plant species grazed or ungrazed
4) Percentage grazed in total area

Besides these, hoof marks of all ungulate species in each sampling plot were recorded and the dropping of all the ungulates were collected and weighed separately. The dropping were then removed from the sample plots to avoid repeated recordings.

Sample plots were divided into ten groups on the basis of vegetation composition as follows;

1) Woodland (WOOD)
2) Scrub woodland (SCW)
3) Dense to discontinuous thickets (DST)
4) Scattered shrubs (SSH)
5) Savannah woodland to scattered tree savannah (SWS)
6) Shrub savannah (SSH)
7) Grass savannah (GRS)

8) Low grassland (LGR)

9) Mosaic of several types (MOS)

10) Wetlands (WET)

Distribution and relative intensity of percentage grazing, area covered by palatable and unpalatable species in different plot were classified into three level of categories namely, low (<25%), medium (25-50%) and large (>50%). Each of these categories were delineated on a map.

The following six criteria related to range condition ~~are~~ were adopted for the present study.

(a) The diversity index of major herb and grass: The diversity was calculated using the Hill diversity index $N1 = e^{H1}$ where H^1 is Shanon's index (Ludwing and Reynolds 1988)

(b) The richness of herbs and grass

(c) Area and volume covered by palatable species

(d) Area and volume covered by unpalatable species

(e) Percentage grazed: percentage grazed in each habitat type

(f) Grazing pressure on 20 major palatable species. The pressure was calculated by the following ratio.

$$\frac{n_i \times n_p}{N^2}$$

n_i = Total number of times species i seen grazed

n_i = Total number of plots

N = Total number of times species i recorded

8.3 Results

8.3.1 Species richness

The species richness during monsoon was maximum in wetland habitat (6.85) and the least in grass savannah (3.5) while during winter the maximum was in low grassland (6.6) and minimum in scattered shrub (2.5). During summer the maximum was in mosaic of several types (5.6) whereas the least was noticed in scattered shrub (1.6) (Table 8.1).

8.3.2 Species diversity

During monsoon the average diversity was maximum (4.36) in low grassland habitat type and the least (2.381) was in scattered shrub (Fig 8.1). During winter the maximum diversity was noticed in a mosaic of several types (5.3) and the least in grass savannah (2.57). In summer also the trend was similar to that in winter (Table 8.2).

The Hill diversity index of each habitat type was compared among the three seasons by using Mann-Whitney test (Table 8.3). Six of the ten habitat types (listed in earlier page) viz WOOD, SCW, DST, SWS, LGR and SHS showed seasonal variation between winter and summer. Only Low grassland habitat (LGR) showed significant variation ($P < 0.04$) between monsoon and winter. Seasonal variation between monsoon and summer was observed in three habitat types viz DST, SWS and SSH.

Table 8.1

Species richness of ground cover

Vegetation	N	Monsoon Mean	Monsoon Min.	Monsoon Max.	Winter Mean	Winter Min.	Winter Max.	Summer Mean	Summer Min.	Summer Max.
WOOD	4	4	2	6	6.5	3	10	3.75	3	4
SCW	15	5	3	9	5.8	3	11	3.9	2	7
DST	22	6	3	10	5.7	3	11	3.6	2	6
SSH	6	4	3	7	2.5	1	5	1.6	1	3
SWS	39	5.7	2	12	4.53	2	7	3.51	1	7
GRS	16	3.5	2	9	3.25	2	5	2.68	2	6
LGR	29	6.24	3	12	6.62	4	11	4.68	3	8
WET	14	6.85	2	11	6.00	3	11	4.5	2	6
SHS	6	4.8	2	8	4.5	1	6	3.5	2	5
MOS	3	5.6	4	7	6.3	5	7	5.6	4	7

N = Number of samples

Table 8.2

Species diversity of ground cover

Vegetation	N	Monsoon Mean	Monsoon Min.	Monsoon Max.	Winter Mean	Winter Min.	Winter Max.	Summer Mean	Summer Min.	Summer Max.
WOOD	4	3.26	1.89	5.45	4.79	2.2	8.07	2.43	2.05	3.0
SCW	15	3.72	1.9	5.5	4.46	1.87	8.14	3.28	1.88	5.7
DST	22	4.30	1.87	6.89	4.59	1.88	7.11	3.33	1.64	5.7
SSH	6	3.28	1.64	4.71	3.06	2.00	4.99	2.58	1.96	3.0
SWS	39	3.55	1.75	7.84	3.35	1.49	5.83	2.69	1.45	5.8
GRS	16	2.89	1.75	8.41	2.57	1.76	4.69	2.33	1.64	4.6
LGR	29	4.36	2.00	6.92	5.27	2.59	9.1	3.83	1.64	7.5
WET	14	4.33	1.26	7.12	5.05	2.68	8.57	3.40	1.87	4.7
SHS	6	3.67	1.64	6.4	4.48	2.92	5.45	2.91	1.64	4.2
MOS	3	3.76	3.38	4.44	5.3	4.35	5.9	5.32	3.92	6.7

N = Number of samples

Table 8.3

Mann Whitney U statistic and significance level (p) calculated for the Hill diversity among the season for different vegetation types

Habitat	Combination	N1	N2	U	P
	M*W	4	4	4.0	0.248
WOOD	W*S	4	4	14.0	0.08
	M*S	4	4	8.0	1.00
	M*W	14	15	74.0	0.176
SCW	W*S	15	14	156.0	0.02
	M*S	14	14	124.0	0.23
	M*W	22	22	215.0	0.526
DST	W*S	22	21	332.0	0.014
	M*S	22	21	312.0	0.049
	M*W	6	6	25.5	0.227
SSH	W*S	6	6	23.0	0.406
	M*S	6	6	31.0	0.036
	M*W	39	39	813.5	0.596
SWS	W*S	39	39	1043.0	0.005
	M*S	39	39	1120.0	0.001
	M*W	16	16	126.5	0.955
GRS	W*S	16	16	163.5	0.17
	M*S	16	16	162.0	0.19
	M*W	29	29	290.5	0.043
LGR	W*S	29	29	620.0	0.002
	M*S	29	29	503.5	0.197
	M*W	14	14	127.0	0.101
WET	W*S	14	14	81.0	0.433
	M*S	14	14	129.5	0.148
	M*W	6	5	8.0	0.201
SHS	W*S	6	6	27.0	0.028
	M*S	6	6	24.5	0.297
	M*W	3	3	1.0	0.127
MOS	W*S	3	3	5.0	0.827
	M*S	3	3	1.0	0.127

M*W = Monsoon x Winter
W*S = Winter x Summer
M*S = Monsoon x Summer

FIG 8.1

THE MEAN PLANT SPECIES DIVERSITY FOR DIFFERENT VEGETATION TYPES

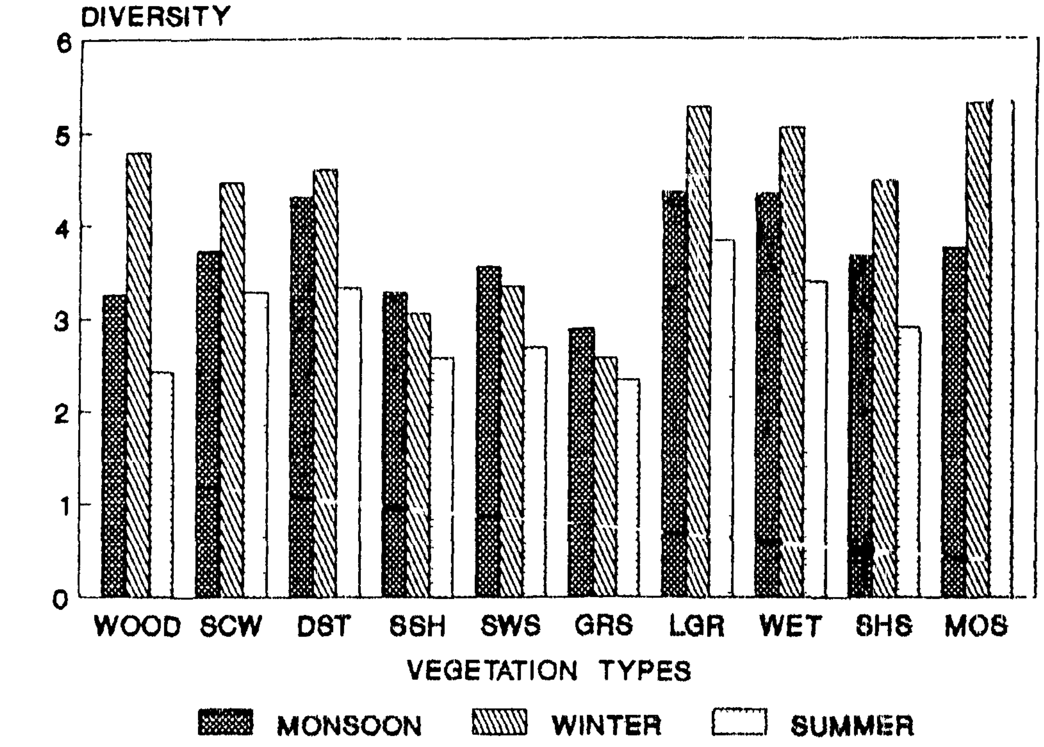
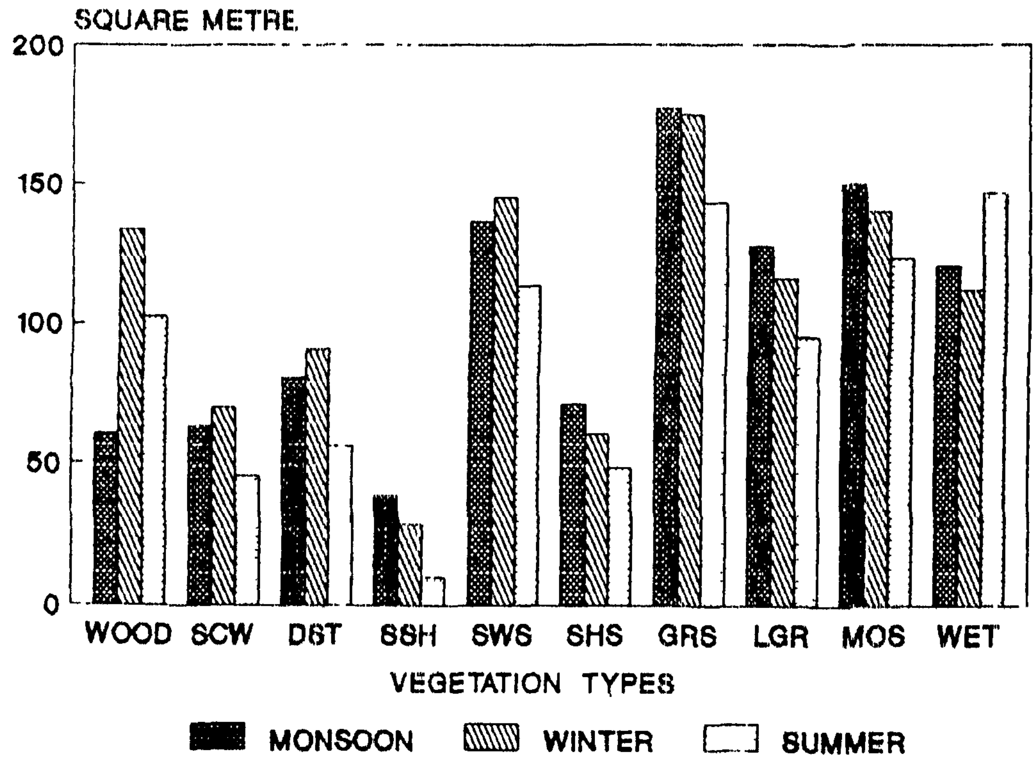


FIG 8.2

THE MEAN AREA COVERED BY PALATABLE SPECIES PER PLOT



8.3.3 Area covered by palatable species

Monsoon

The total area covered by palatable species in all the ten habitat types was 1023.88 m^2. The maximum area covered with ground vegetation was in grass savannah (176.9 m^2) while the least was is scattered shrub (38.17 m^2) (Fig 8.2).

Winter

The total area covered by palatable species in all habitat types taken together,during winter was 1069.88 m^2. During winter the maximum was in grass savannah (174.69 m^2) and least in scattered shrub (28.33 m^2) which is considerably less compared to that in monsoon (Fig 8.2).

Summer

During summer the area covered by palatable species in all the habitat taken together was less (983.02 m^2) compared to in other two seasons. The maximum area covered was in wetland (146.43 m^2) habitat type and the least in the scrub woodland (45.33 m^2) (Fig 8.2).

The area covered by palatable species in each habitat type during the three seasons was compared, namely monsoon, winter and summer using Mann-Whitney 'U' test. Variation was noticed between winter and summer, and between monsoon and summer mainly in scrub woodland, scattered shrub, savannah woodland to

FIG 8.3

SEASONAL AND SPATIAL VARIATION OF THE AREA COVERED BY PALATABLE SPECIES

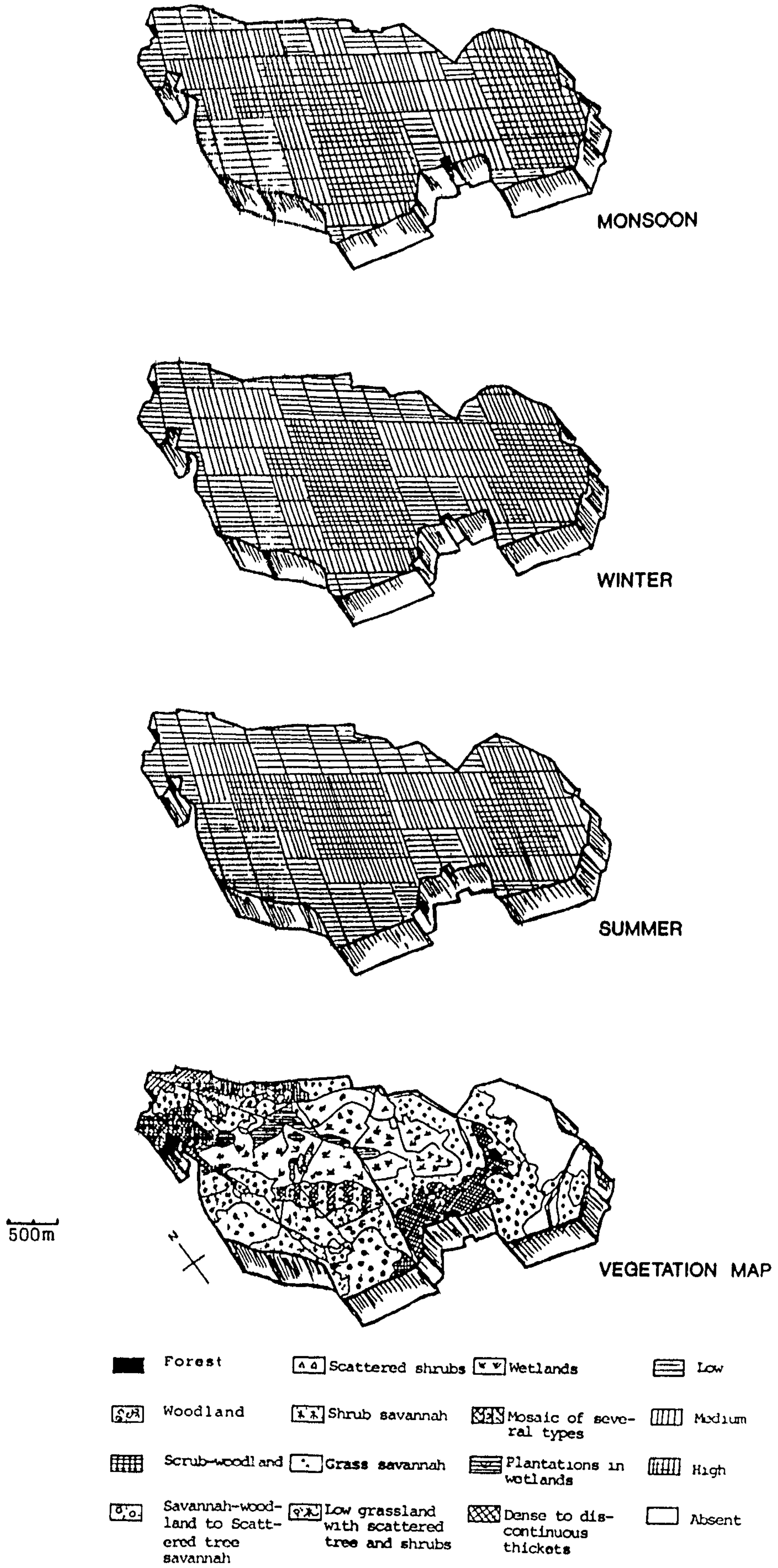


Table 8.4

Mann Whitney U statistic and significance level (p) calculated for the area covered by palatable species among the season for different vegetation types

Habitat	Combination	N1	N2	U	P
	M*W	4	4	14.0	0.02
WOOD	W*S	4	4	9.0	0.772
	M*S	4	4	4.0	0.243
	M*W	14	15	83.5	0.346
SCW	W*S	15	15	160.0	0.048
	M*S	14	15	146.0	0.072
	M*W	22	22	212.0	0.48
DST	W*S	22	22	350.0	0.011
	M*S	22	22	311.0	0.10
	M*W	6	6	23.5	0.37
SSH	W*S	6	6	32.0	0.01
	M*S	6	6	32.5	0.016
	M*W	38	38	694.5	0.775
SWS	W*S	38	38	945.5	0.02
	M*S	38	38	903.5	0.058
	M*W	16	16	130.0	0.935
GRS	W*S	16	16	179.5	0.039
	M*S	16	16	173.0	0.076
	M*W	29	29	486.5	0.304
LGR	W*S	29	29	518.5	0.126
	M*S	29	29	593.0	0.007
	M*W	14	7	56.5	0.57
WET	W*S	7	14	26.5	0.08
	M*S	14	14	60.5	0.08
	M*W	6	6	20.0	0.748
SHS	W*S	6	6	21.5	0.56
	M*S	6	6	24.5	0.293
	M*W	3	3	4.0	0.827
MOS	W*S	3	3	7.0	0.275
	M*S	3	3	9.0	0.05

M*W = Monsoon x Winter
W*S = Winter x Summer
M*S = Monsoon x Summer

Table 8.5

Two factor analysis of variance on the area covered by palatable species

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
Season	21510.916	2	10755.458	5.059	0.007
Habitat	569615.366	9	63290.596	29.767	0.001
Season* Habitat	45367.803	18	2520.434	1.185	0.269

Table 8.6

Two factor analysis of variance on the volume occupied by palatable species

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
Season	20929.360	2	10464.680	8.041	0.001
Habitat	358596.195	9	39844.022	30.617	0.001
Season* Habitat	57405.728	18	3189.207	2.451	0.001

scattered savannah, grass savannah, and wetland. The area covered by palatable species in woodland shows the variation only between monsoon and winter, whereas dense to discontinuous showed variation only between winter and summer. On the other hand, in low grassland and mosaic of several types there was variation only between monsoon and summer (Fig 8.3). The only habitat which did not show any seasonal variation was shrub savannah (Table 8.4).

Two factor analysis of variance shows that there was a significant seasonal ($P < 0.001$) and habitat ($P < 0.001$) variation in the area covered by the palatable species (Table 8.5).

8.3.4 Volume of space occupied by palatable species

Monsoon

The total volume occupied by palatable species in all the habitat types was 424.54 m^3 during monsoon. It varied from 6.5 m^3 in scattered shrub to 124.61 m^3 in grass savannah (Fig 8.4).

Winter

The total volume occupied by palatable species during winter (406.79 m^3) was less compared to that in monsoon season. The total volume occupied is less during winter compared to that during monsoon. It varied from 124.12 m^3 in grass savannah to 4.38 m^3 in scattered shrub (Fig 8.4).

FIG 8.4

THE MEAN VOLUME OF PALATABLE SPECIES PER PLOT

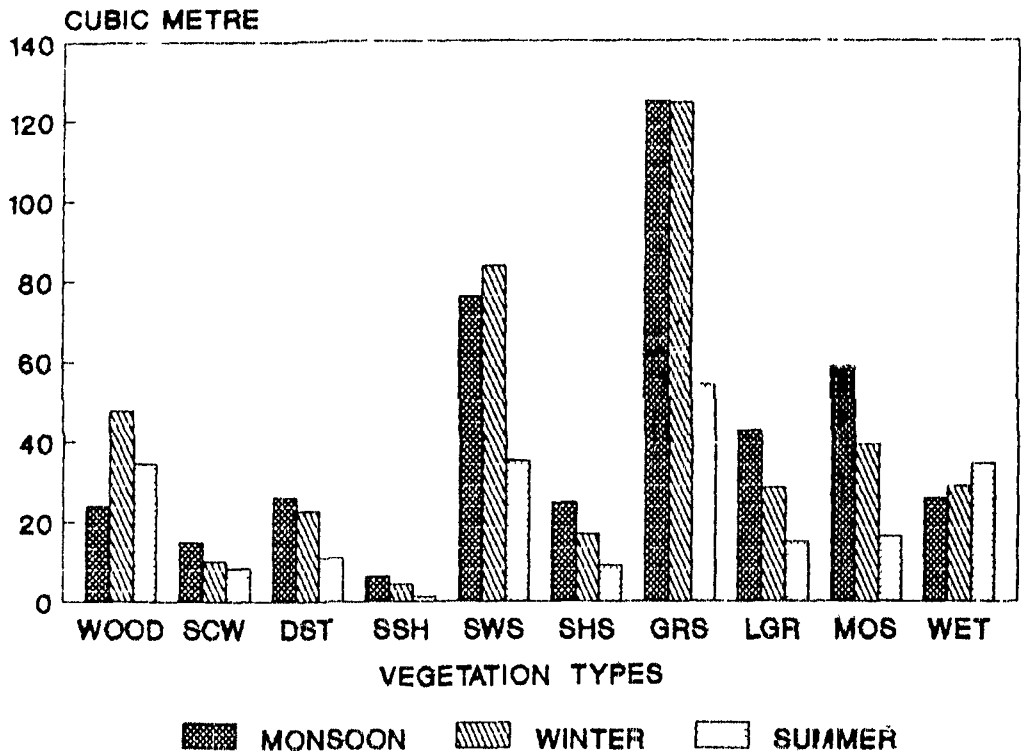


FIG 8.5

THE MEAN AREA COVERED BY UNPALATABLE SPECIES PER PLOT

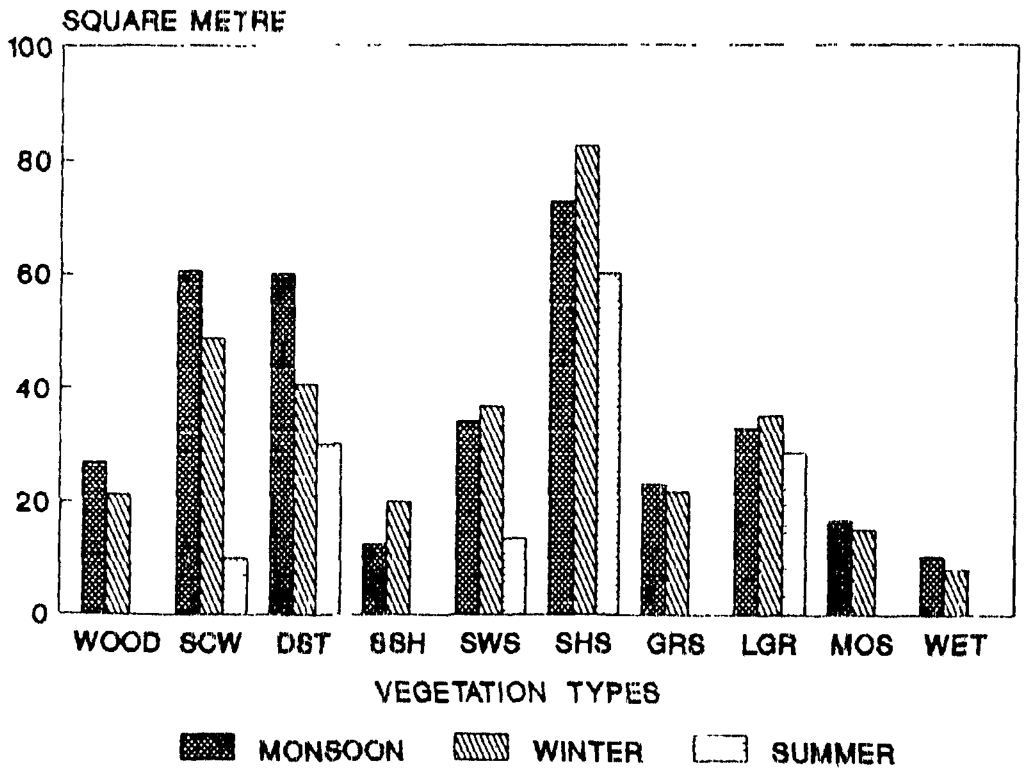


Table 8.7

Mann Whitney U statistic and significance level (p) calculated for the volume of palatable species among the season for different vegetation types

Habitat	Combination	N1	N2	U	P
	M*W	4	4	3.0	0.149
WOOD	W*S	4	4	11.0	0.386
	M*S	4	4	7.0	0.773
	M*W	14	15	133.0	0.22
SCW	W*S	14	15	158.0	0.05
	M*S	14	15	166.0	0.008
	M*W	22	22	292.0	0.241
DST	W*S	22	22	349.0	0.012
	M*S	22	22	372.0	0.002
	M*W	6	6	22.0	0.522
SSH	W*S	6	6	28.0	0.109
	M*S	6	6	31.0	0.037
	M*W	38	38	676.0	0.633
SWS	W*S	38	38	1109.0	0.001
	M*S	38	38	1057.0	0.001
	M*W	16	16	126.0	0.94
GRS	W*S	16	16	205.0	0.004
	M*S	16	16	210.0	0.002
	M*W	29	29	590.0	0.008
LGR	W*S	29	29	609.5	0.003
	M*S	29	29	740.0	0.001
	M*W	14	7	33.0	0.23
WET	W*S	7	14	44.0	0.709
	M*S	14	14	71.0	0.215
	M*W	6	6	24.0	0.337
SHS	W*S	6	6	32.0	0.025
	M*S	6	6	33.0	0.016
	M*W	3	3	6.0	0.513
MOS	W*S	3	3	9.0	0.05
	M*S	3	3	9.0	0.05

M*W = Monsoon x Winter
W*S = Winter x Summer
M*S = Monsoon x Summer

Summer

The total volume occupied by palatable species in all the habitat types was 219.51 m^3. Like in other seasons, the maximum (54.18 m^3) was in grass savannah and least (1.42 m^3) in scattered shrubs (Fig 8.4).

The analysis of variance for the volume occupied by palatable species shows that there was significant variation from one habitat type to another and also seasonal variations in habitats. (Table 8.6).

The volume occupied by palatable species shows a significant variation between winter and summer and between monsoon and summer for scrub woodland, dense to discontinuous thickets, savannah woodland to scattered savannah, grass savannah, shrub savannah and mosaic of several habitat types, whereas scattered shrub differed only between monsoon and summer. The low grassland habitat showed variation in all the season - combinations while woodland and wetland did not show any seasonal variation (Table 8.7).

8.3.5 Area covered by unpalatable species

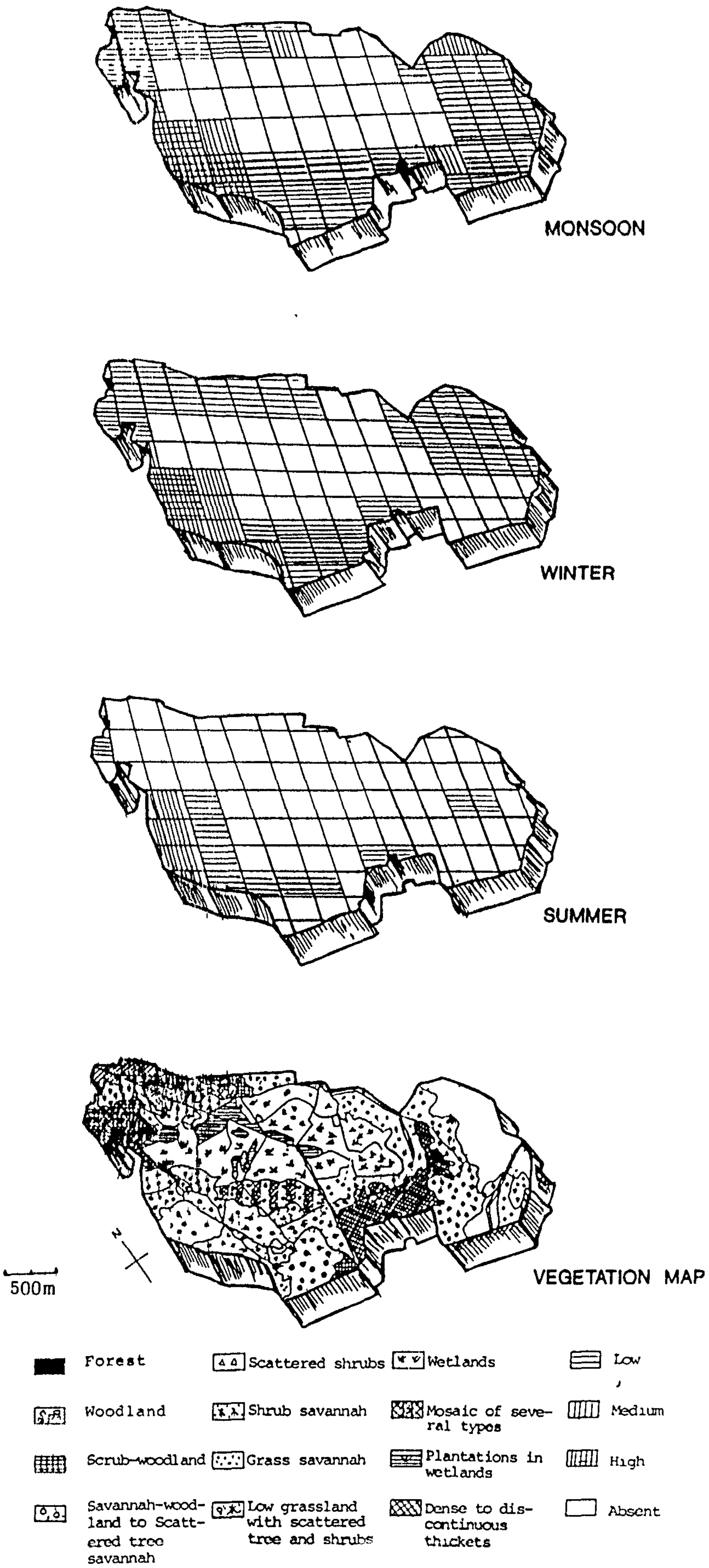
The most common unpalatable species are *Cassia tora* and *Achyranthes aspera*.

Monsoon

The total area covered by unpalatable species in all the habitat types together was 349.09 m^2 which is around 25% of the

FIG 8.6

SEASONAL AND SPATIAL VARIATION OF THE AREA COVERED BY UNPALATABLE SPECIES



total area covered by vegetation. The maximum area covered by unpalatable species was found in shrub savannah (72.60 sq m) and the least in wetland (10.30 m^2) (Fig 8.5).

Winter

Of the total area covered by ground vegetation around 23% was found occupied by unpalatable species during winter. During this season also the maximum area covered by unpalatable species was in shrub savannah (82.5 m^2) and the least in wetland (8.00 m^2).

Summer

Area covered by unpalatable species in all the habitats taken together was 142.07 m^2; approximately 13% of the total area covered by ground vegetation. The maximum was noticed in shrub savannah (60.00 m^2) and the least in scrub woodland (10.00 m^2). During this season the unpalatable species were almost absent in woodland, scattered shrub, grass savannah, mosaic of several types and wetland (Fig 8.6).

The area covered by unpalatable species in each habitat type during the three seasons was compared using Mann-Whitney test. Variation was noticed between winter and summer, and monsoon and summer mainly in woodland, scrub-woodland, savannah-woodland to scattered tree savannah, grass savannah and low grassland. Wetland and scattered shrub did not show any variation between winter and summer. Mosaic of several habitat type showed the difference only between monsoon and summer ($P < 0.05$) whereas

Table 8.8

Mann Whitney U statistic and significance level (p) calculated for the area covered by unpalatable species among the season for different vegetation types

Habitat	Combination	N1	N2	U	P
	M*W	4	4	10.5	0.462
WOOD	W*S	4	4	16.0	0.013
	M*S	4	4	16.0	0.013
	M*W	14	14	113.5	0.475
SCW	W*S	14	14	193.5	0.001
	M*S	14	14	189.0	0.001
	M*W	22	22	330.5	0.037
DST	W*S	22	22	411.0	0.001
	M*S	22	22	463.5	0.001
	M*W	5	5	21.0	0.066
SSH	W*S	5	5	15.0	0.317
	M*S	5	5	25.0	0.005
	M*W	38	38	684.0	0.692
SWS	W*S	38	38	1207.5	0.001
	M*S	38	38	1220.5	0.001
	M*W	6	6	17.0	0.87
SHS	W*S	6	6	25.0	0.231
	M*S	6	6	26.0	0.171
	M*W	15	15	117.0	0.801
GRS	W*S	15	15	135.0	0.073
	M*S	15	15	142.5	0.035
	M*W	29	29	422.5	0.975
LGR	W*S	29	29	635.0	0.001
	M*S	29	29	639.5	0.001
	M*W	3	3	5.0	0.827
MOS	W*S	3	3	7.5	0.121
	M*S	3	3	9.0	0.037
	M*W	14	14	140.5	0.014
WET	W*S	14	14	105.0	0.317
	M*S	14	14	147.0	0.003

M*W = Monsoon x Winter
W*S = Winter x Summer
M*S = Monsoon x Summer

dense to discontinuous thicket showed the variation in all the three seasonal combinations. The only habitat which did not show any seasonal variation shrub savannah (Table 8.8).

Analysis of variance for the area covered by unpalatable species shows that there was significant variation from one to the other habitat type and also from one to other season (Table 8.9).

8.3.6 Volume occupied by the unpalatable species

Monsoon

Volume occupied by unpalatable species in all the habitat types taken together was 144.39 m^3 which is around 25% of the total volume occupied by vegetation. The maximum volume occupied by unpalatable species was in shrub savannah (30.23 m^3) and the least in wetland (2.08 m^3) (Fig 8.7).

Winter

Of the total volume covered by ground vegetation, 33.33% was occupied by unpalatable species during winter. As in monsoon, the maximum volume occupied by unpalatable species in winter was in shrub savannah (66.85 m^3) and the least in the wetland (3.34 m^3).

Summer

The total volume occupied by unpalatable species during summer was 142.07m^3 which is 22% of the total volume occupied by

FIG 8.7

THE MEAN VOLUME OF UNPALATABLE SPECIES PER PLOT

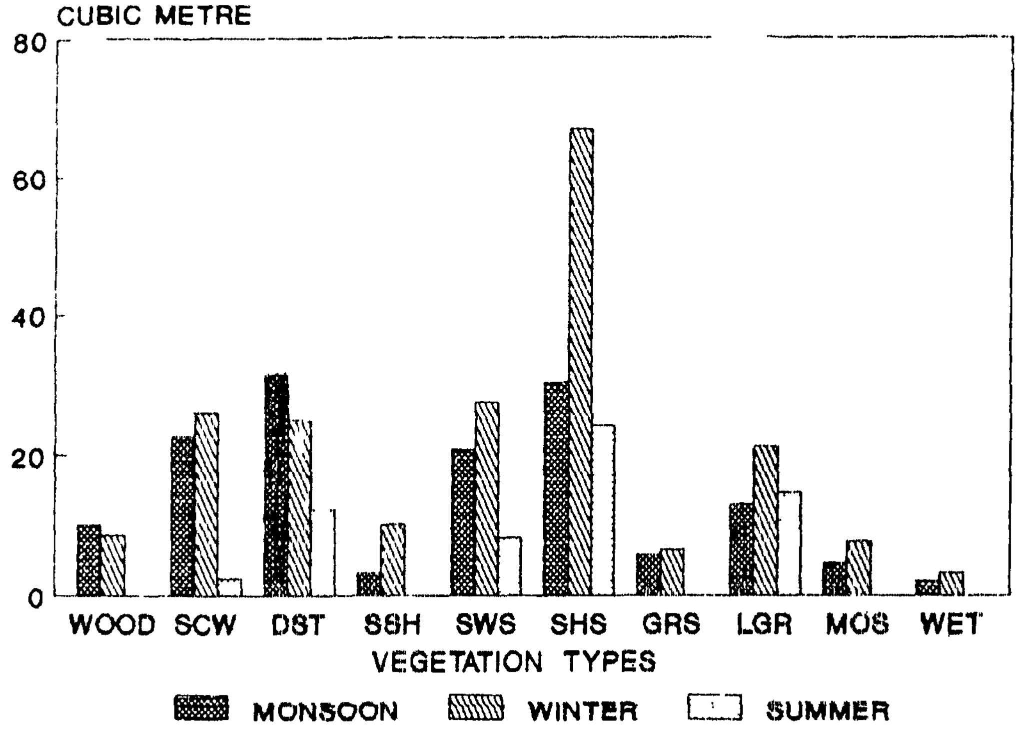


FIG 8.8

THE MEAN PERCENTAGE GRAZED PER PLOT IN DIFFERENT TYPES OF VEGETATION

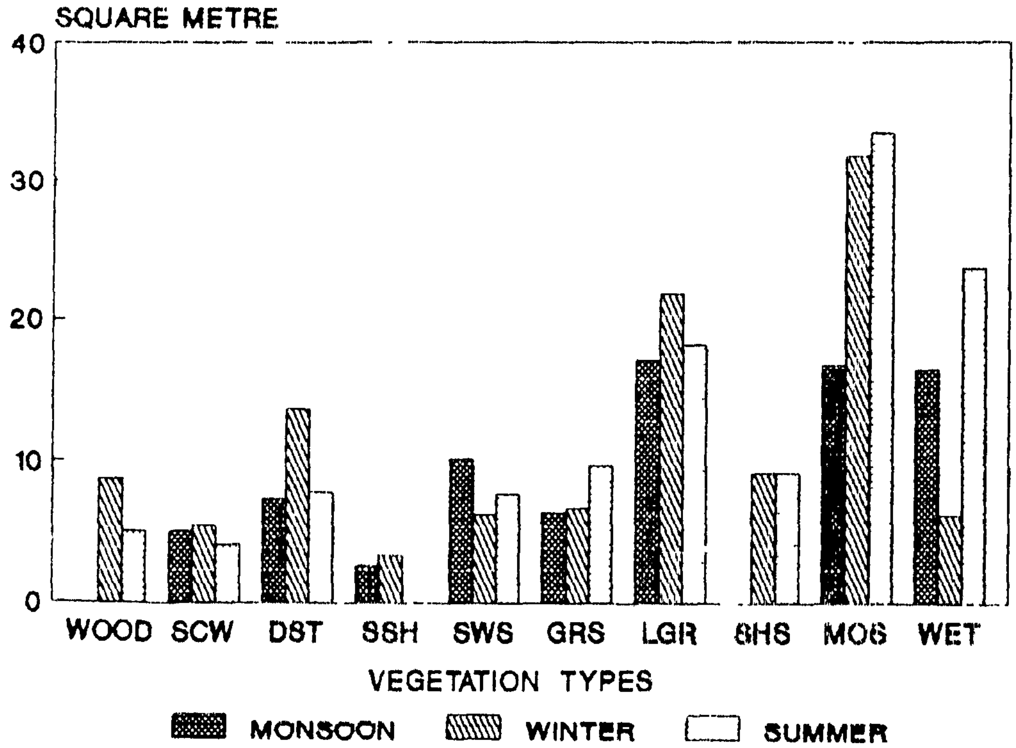


Table 8.9

Two factor analysis of variance on the area covered by unpalatable species

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
Season	24226.773	2	12113.386	17.364	0.001
Habitat	56887.301	9	6320.811	9.061	0.001
Season* Habitat	23128.535	18	1284.919	1.842	0.019

Table 8.10

Two factor analysis of variance on the volume occupied by unpalatable species

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
Season	7529.946	2	3764.973	11.363	0.001
Habitat	19006.791	9	2111.866	6.374	0.001
Season* Habitat	11267.745	18	625.986	1.889	0.015

Table 8.11

Mann Whitney U statistic and significance level (p) calculated for the volume of unpalatable species among the season for different vegetation types

Habitat	Combination	N1	N2	U	P
	M*W	4	4	10.0	0.564
WOOD	W*S	4	4	16.0	0.014
	M*S	4	4	16.0	0.014
	M*W	15	15	104.5	0.74
SCW	W*S	15	15	213.5	0.001
	M*S	15	15	208.5	0.001
	M*W	22	22	283.0	0.336
DST	W*S	22	22	419.0	0.001
	M*S	22	22	462.0	0.001
	M*W	6	6	28.5	0.073
SSH	W*S	6	6	21.0	0.317
	M*S	6	6	33.0	0.007
	M*W	38	38	604.0	0.218
SWS	W*S	38	38	1206.0	0.001
	M*S	38	38	1192.5	0.001
	M*W	16	16	136.0	0.677
GRS	W*S	16	16	152.0	0.074
	M*S	16	16	160.0	0.036
	M*W	29	29	372.0	0.45
LGR	W*S	29	29	643.5	0.001
	M*S	29	29	626.0	0.001
	M*W	6	6	16.0	0.744
SHS	W*S	6	6	25.0	0.232
	M*S	6	6	25.0	0.232
	M*W	3	3	5.0	0.827
MOS	W*S	3	3	7.5	0.121
	M*S	3	3	9.0	0.037
	M*W	12	12	105.5	0.021
WET	W*S	12	12	78.0	0.317
	M*S	12	12	114.0	0.003

M*W = Monsoon x Winter
W*S = Winter x Summer
M*S = Monsoon x Summer

ground vegetation. The volume occupied by unpalatable species was maximum in shrub savannah (60 m^3) and least in scrub woodland (10.00 m^3) (Fig 8.7).

The analysis of variance shows that there was significant seasonal variation ($P < 0.001$) and also from one to the other habitat ($P < 0.001$) variation in the volume occupied by unpalatable species (Table 8.10).

The volume occupied by unpalatable species showed a significant variation between winter and summer and between monsoon and summer for woodland, scrub woodland, dense to discontinuous thickets, savannah woodland to scattered tree savannah, grass savannah and low grassland, whereas scattered shrub and wetland did not differed only between winter and summer. On the other hand, volume covered by unpalatable species for shrub savannah did not show any significant seasonal variation (Table 8.11).

8.3.7 Percentage grazed

Monsoon

The average percentage of herbs and grasses grazed in all the habitat types during monsoon was 8.1%. It varied from 2.5% in scattered shrub to 17.06% in low grassland. The percentage grazed in different seasons was the same (16%) in mosaic of several types and in wetland (Fig 8.8).

FIG 8.9

SEASONAL AND SPATIAL VARIATION OF GRAZING INTENSITY BY UNGULATES

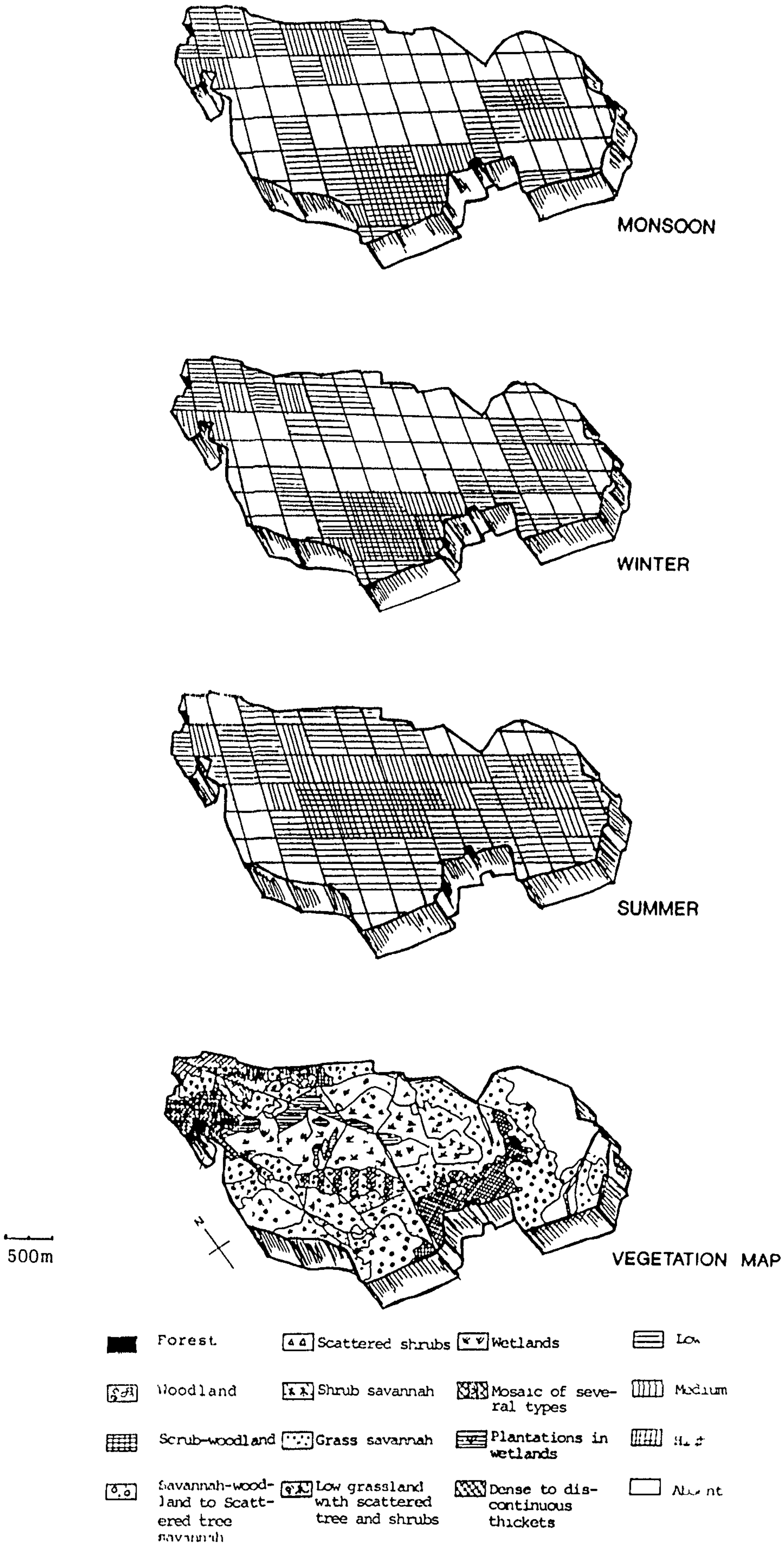


Table 8.12

Mann Whitney U statistic and significance level (p) calculated for the percentage grazed among the season for different vegetation types

Habitat	Combination	N1	N2	U	P
	M*W	4	4	13.0	0.013
WOOD	W*S	4	4	11.5	0.278
	M*S	4	4	2.0	0.046
	M*W	15	15	108.0	0.835
SCW	W*S	15	15	110.0	0.912
	M*S	15	15	107.5	0.824
	M*W	22	22	186.0	0.173
DST	W*S	22	22	301.0	0.155
	M*S	22	22	239.0	0.942
	M*W	6	6	28.0	1.00
SSH	W*S	6	6	24.0	0.138
	M*S	6	6	27.0	0.056
	M*W	39	39	852.0	0.327
SWS	W*S	39	39	607.5	0.099
	M*S	39	39	758.5	0.983
	M*W	16	16	127.5	0.983
GRS	W*S	16	16	93.0	0.163
	M*S	16	16	91.5	0.143
	M*W	29	29	354.5	0.283
LGR	W*S	29	29	482.5	0.321
	M*S	29	29	413.5	0.911
	M*W	6	6	6.0	0.022
SHS	W*S	6	6	17.0	0.867
	M*S	6	6	3.0	0.006
	M*W	3	3	3.0	0.487
MOS	W*S	3	3	3.5	0.637
	M*S	3	3	2.0	0.197
	M*W	14	14	147.5	0.016
WET	W*S	14	14	33.5	0.002
	M*S	14	14	70.0	0.182

M*W = Monsoon x Winter
W*S = Winter x Summer
M*S = Monsoon x Summer

Winter

The average percentage grazed during winter was 11.2%. The maximum percentage grazed was noticed in mosaic of several types (31.6%) followed by low grassland (21.7%) and least in scattered shrub (3.33%) (Fig 8.8).

Summer

During summer the average percentage grazed was slightly higher (11.8%) than that in winter. The maximum percentage grazed was in mosaic of several types (33.33%) followed by wetland (23.57%) and the least in scrub woodland (Fig 8.9). Not even a single plot was grazed in scattered shrub during this season.

The percentage grazed in different habitat types was compared among the seasons using Mann-Whitney test. The variation between monsoon and winter and between monsoon and summer was noticed only in woodland and shrub savannah habitat types. Grazing in scattered shrub habitat type differed only between monsoon and summer, whereas, it differed in savannah woodland to scattered tree savannah between winter and summer. Variation in grazing in wetland was observed between monsoon and winter and between winter and summer. On the other hand, scrub woodland, grass savannah,,low grassland, and mosaic of several type did not show any seasonal variation (Table 8.12).

8.3.8 Presence of hoof marks and droppings in different vegetation type

With the aim of finding out relative use of each habitat type in different seasons, the presence of droppings and hoof marks were taken as measures. Either of these two evidences indicate the presence of animals in a habitat.

Since hoof marks are not always clear in certain habitats such as when the ground surface is hard or is thickly covered with grass, droppings indicate the habitat use. But droppings are usually not in the form of definite groups or heaps and therefore their weight has been taken as a measure of animal number and duration of their stay in the concerned habitat.

Similarly in certain habitat types, droppings are difficult to locate and hence hoof marks abundance has been taken as indication of the animal number or duration of their stay both indirectly giving an idea of habitat use.

The sighting of hoof marks in various plots was recorded in each season and an index (n) was developed for each vegetation type as follows:

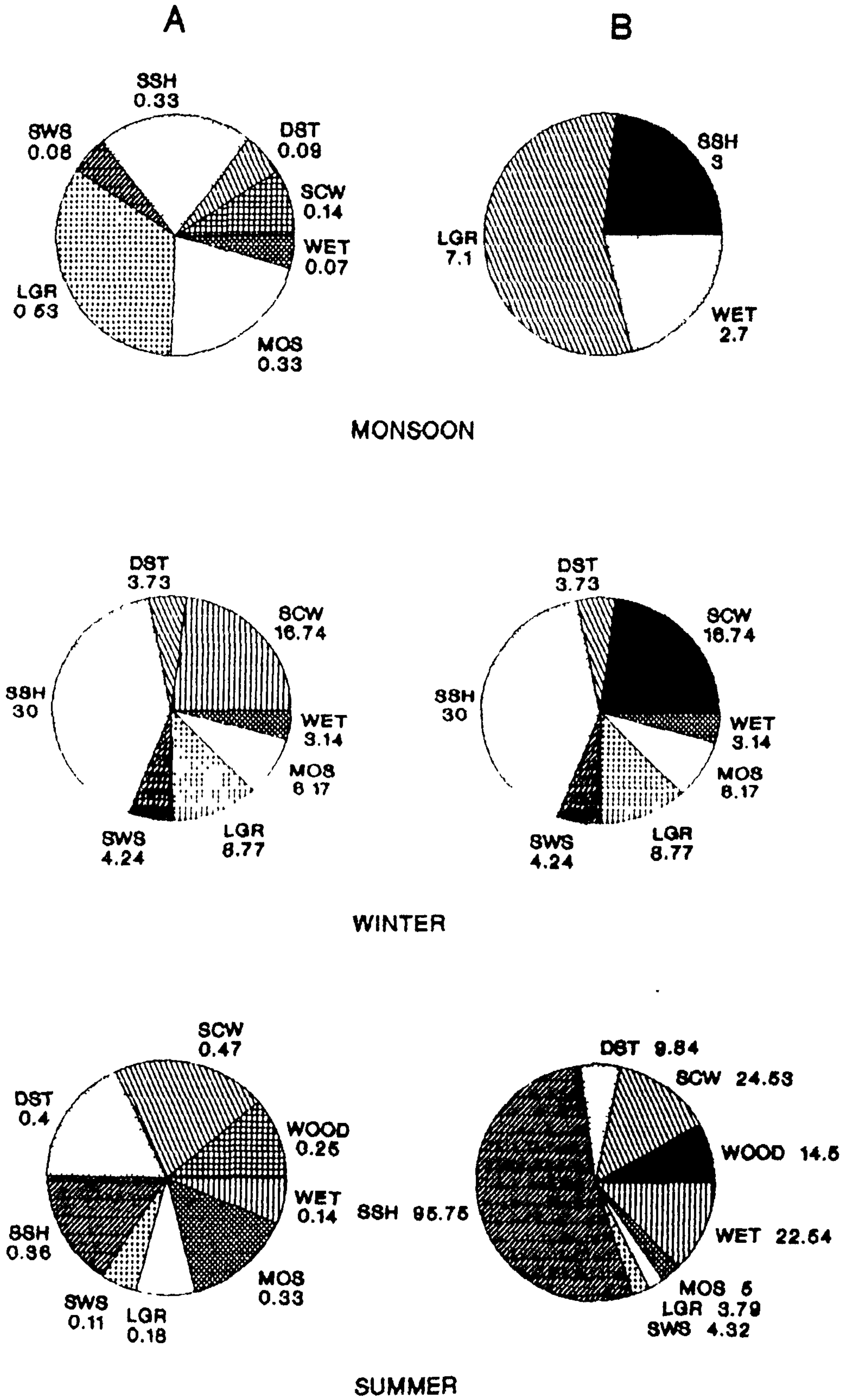
$$n = X_{ij} / N_j$$

Similarly, an index for droppings was developed as follows:

$$n = W_{ij} / N_j$$

FIG 8.10

Average (a) sightings of hoof marks and (b) droppings (in gms) of Chital per plot in different vegetation types



where,

i = Species

j = Habitat

X = No. of hoof marks sighted

W = Weight of dropping in gms

N = Number of plots

CHITAL

During monsoon and winter maximum number of hoof marks were sighted in low grassland, mosaic of several type and scattered shrub while minimum in savannah woodland to scattered tree savannah. But, during summer the maximum number of hoof marks were sighted in scrub woodland and dense to discontinuous thickets and least in savannah woodland to scattered tree savannah (Fig 8.10 a).

The trend was somewhat different in regard to droppings. During monsoon the maximum number of dropping were found in low grassland and least in wetland. During winter and summer maximum number of dropping were found in scattered shrub. Minimum number of dropping were located in wetland during winter while during summer the least number of droppings were located in grassland (Fig 8.10 b).

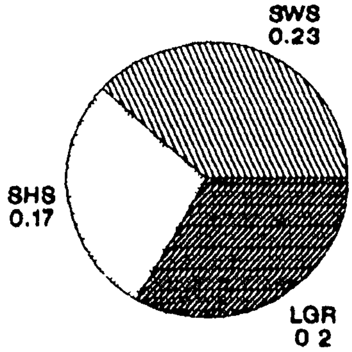
The high index of hoof marks and droppings in scattered shrub can be explained as follows. The scattered shrubs are widely found, especially in saline zone and consists of *Salvadora* sp. and *Prosopis juliflora* which are mainly used as resting place

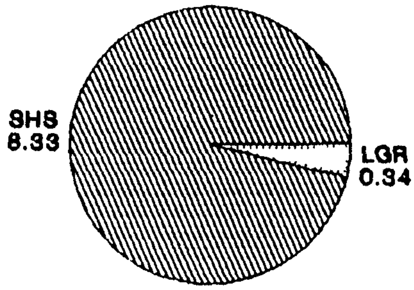
FIG 8.11

Average (a) sightings of hoof marks and (b) droppings (in gms) of Blackbuck per plot in different vegetation types

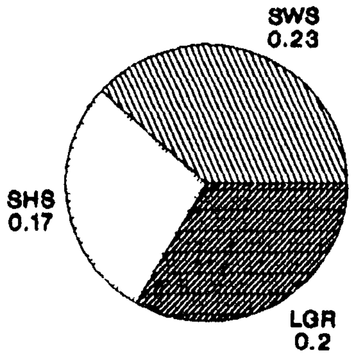
A

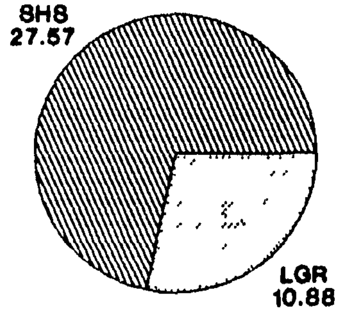
B



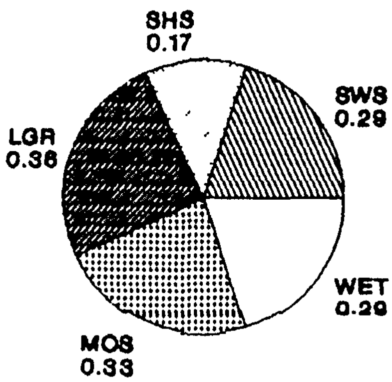


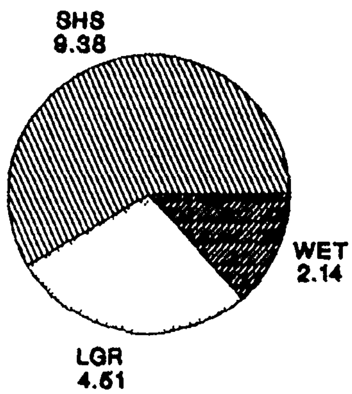
MONSOON





WINTER





SUMMER

by Chital. The other possible reason for high index of hoof marks in this habitat may be the lack of ground cover in saline patch making the hoof very conspicuous.

BLACKBUCK

During monsoon and winter seasons the maximum hoof marks of Blackbuck were seen in savannah woodland to scattered tree savannah while during summer the maximum number were seen in low grassland area. In all the three seasons the minimum number of hoof marks were found in shrub savannah habitat (Fig 8.11 a).

In all the three seasons the maximum droppings were found in shrub savannah and minimum in low grassland habitat. But in summer the maximum droppings were found in wetland habitat (Fig 8.11 b).

The frequency of hoof marks and droppings of Blackbuck was present in various habitat types during summer than during monsoon and winter which may be because of the shortage of food in a given habitat and the necessity of covering longer areas in search of food.

NILGAI

The maximum number of hoof marks of nilgai were sighted during monsoon and summer in savannah woodland to scattered tree savannah followed by scrub woodland, whereas, during winter the maximum was in mosaic of several types followed by dense to discontinuous thickets (Fig 8.12 a).

FIG 8.12

Average (a) sightings of hoof marks and (b) droppings (in gms) of Nilgai per plot in different vegetation types

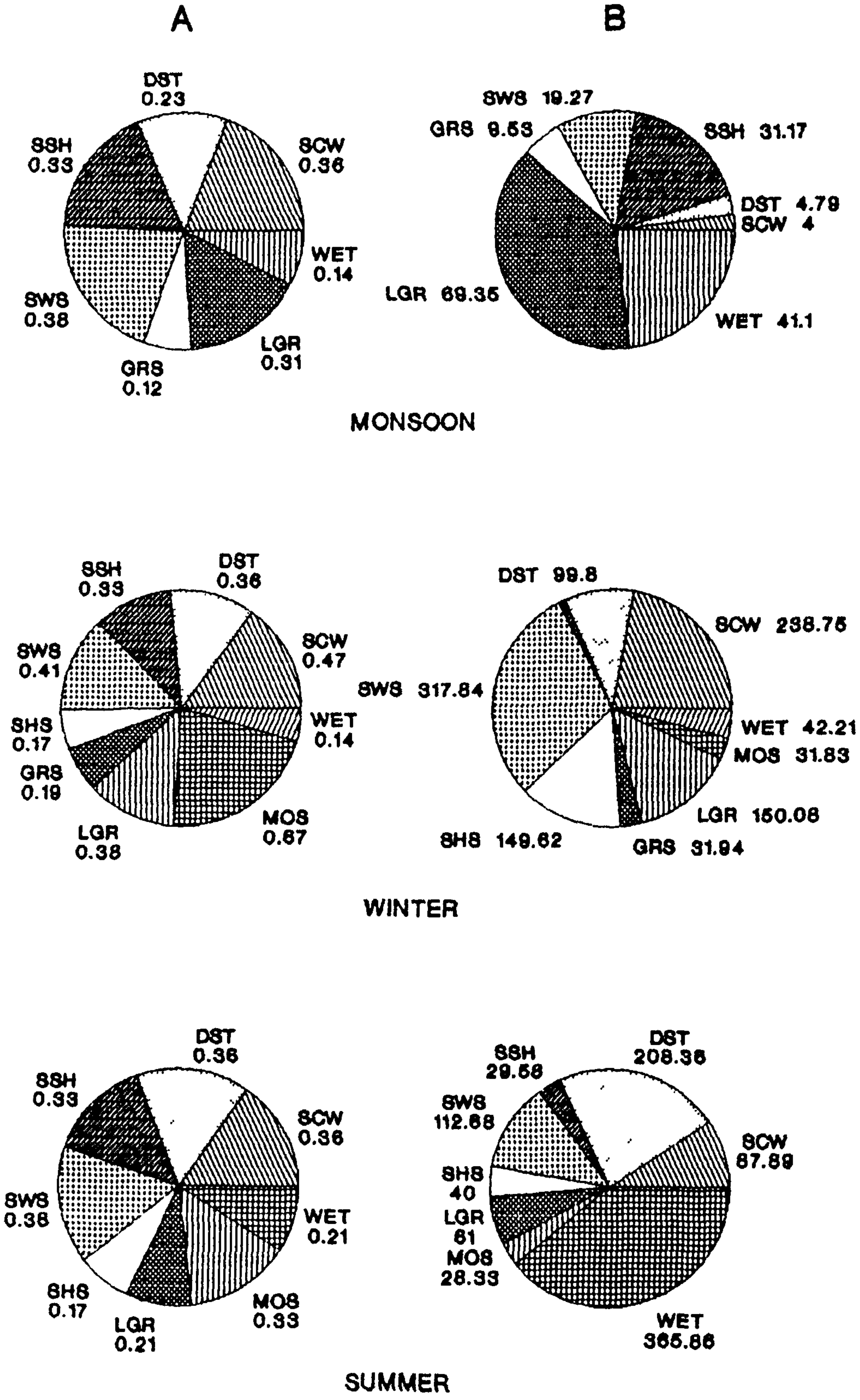
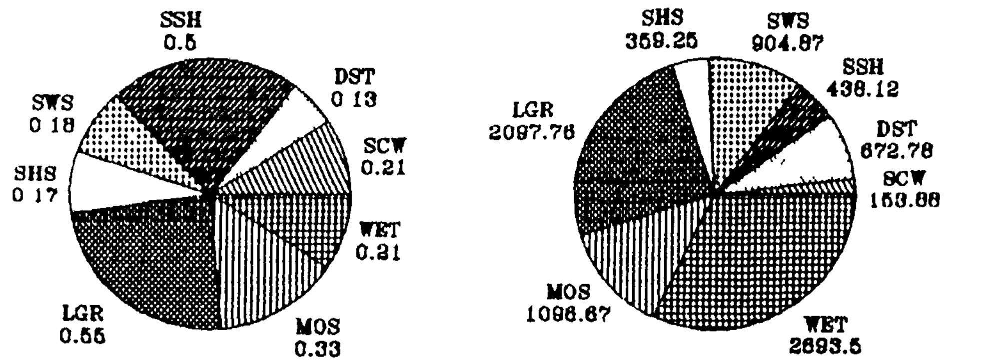


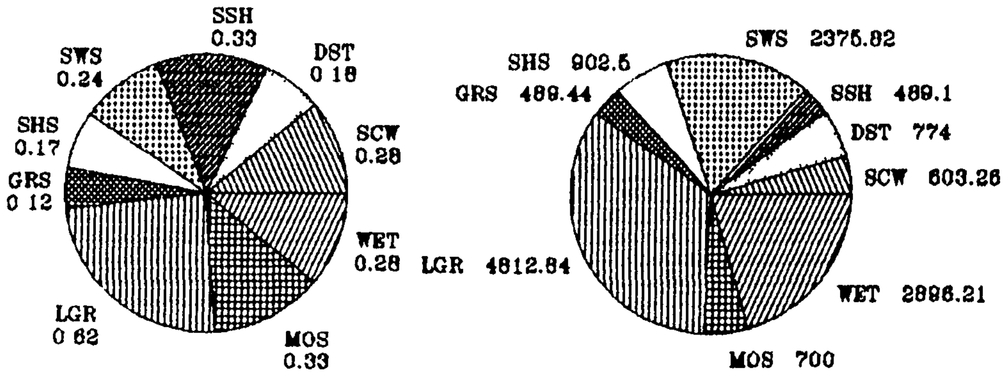
FIG 8.13

Average (a) sightings of hoof marks and (b) droppings (in gms) of Feral cattle per plot in different vegetation types

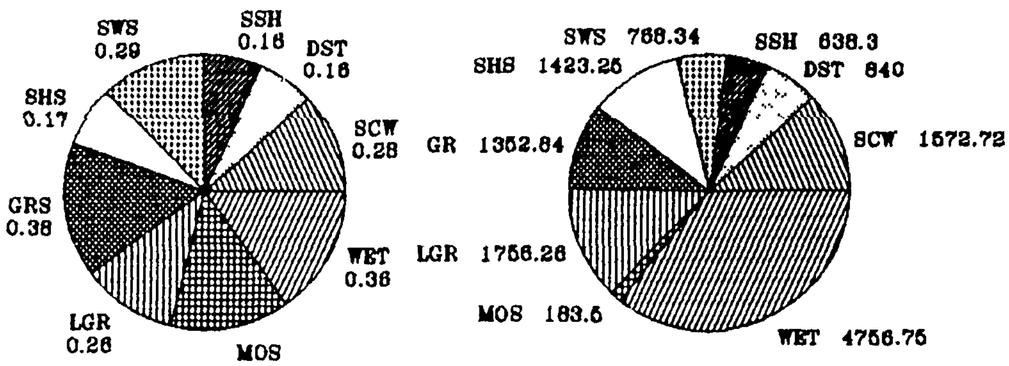
A B



MONSOON



WINTER



SUMMER

Distinct seasonal variation in the presence of Nilgais' droppings in different habitats was observed. Maximum droppings were found in low grassland during monsoon, in savannah woodland to scattered tree savannah in winter season and in wetland habitat during summer (Fig 8.12 b).

Presence of droppings in the case of Nilgai may create a bias result because of its characteristic habit of defecating repeatedly in the same location, with the result of forming large fecal masses .The size of the dropping pile varies from 0.1 sq.m. to 2 sq.m. and hence the weight.

FERAL CATTLE

During monsoon and winter the maximum hoof marks of feral cattle was seen in low grassland which is the most preferred habitat of feral cattle. Few hoof marks were seen in shrub savannah during winter. During summer, however, almost equal number of hoof marks of feral cattle were seen in grass savannah, mosaic of several types and wetland (Fig 8.13 a).

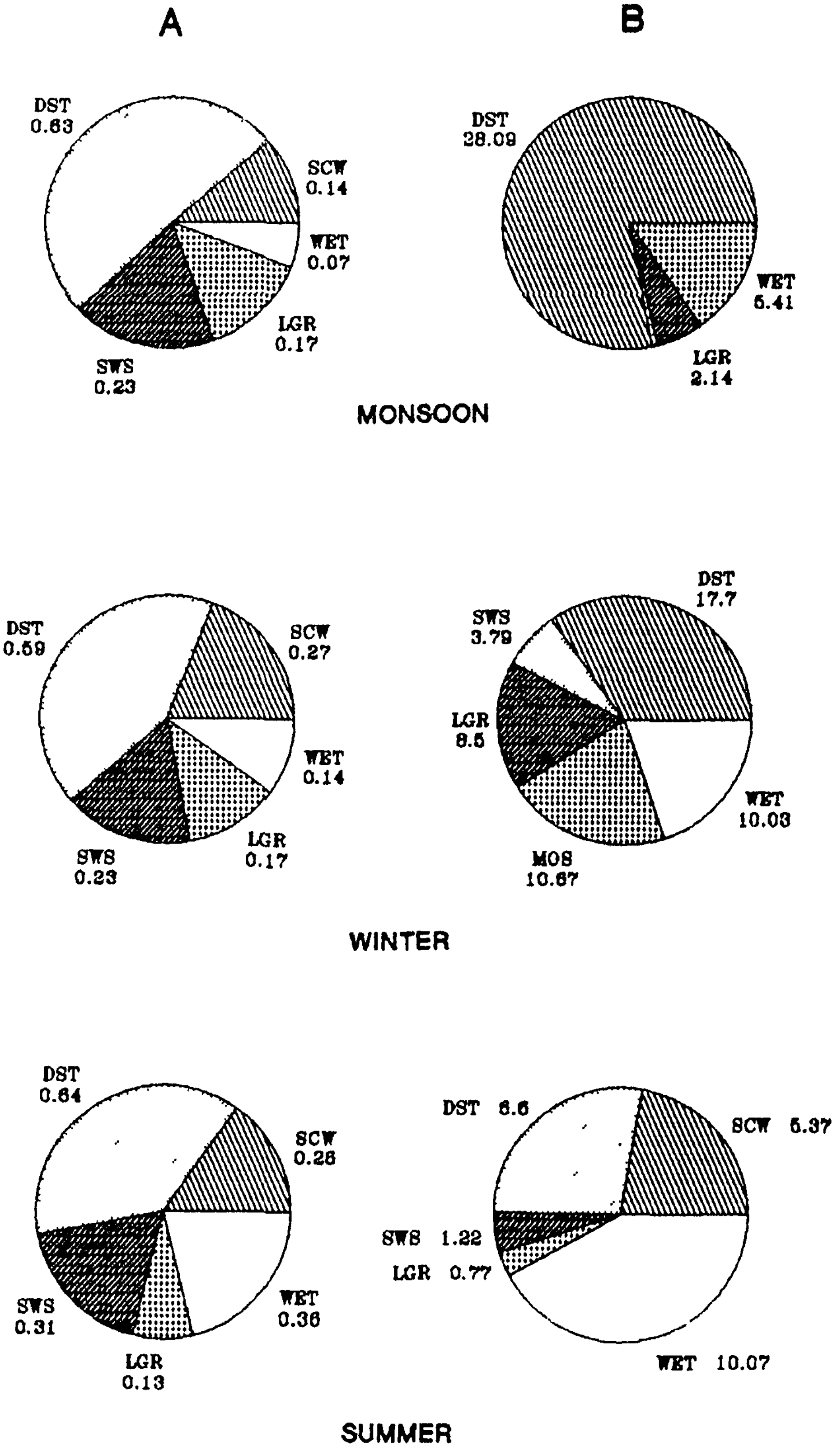
The trend of distribution of droppings was more or less similar to hoof marks. During monsoon and winter the maximum dropping were collected from low grassland area and least from scrub woodland. But, during summer the maximum droppings were collected from wetland habitat (Fig 8.13 b).

WILD BOAR

In all the three seasons, namely monsoon, winter and summer the maximum hoof marks and dropping were found present in dense

FIG 8.14

Average (a) sightings of hoof marks and (b) droppings (in gms) of Wild boar per plot in different vegetation types



to discontinuous thickets (Fig 8.14 a & b). This indicates that Wild boar mainly prefer dense to discontinuous thickets and scrub woodland.

8.3.9 Abundance of major plant species in different habitat types

Abundance of 20 major palatable species of grasses and herbs were estimated. All the 20 species were found during winter season but 19 were found in monsoon and 17 in summer season. The volume of space occupied by each species was calculated as follows:

Circular sample plots of 8 m radius (different number in each habitat type) were laid. Volume of space occupied by each species in all plots was estimated and average per 200 m^2 was calculated. This figure was taken as an abundance ratio.

Monsoon

During monsoon *Cynodon dactylon* , *Cyperus* spp., *Echinocloa* spp., *Sporobolus* spp., *Scirpus* spp., and *Bracharia* spp. was recorded in most of the habitats. *Cynodon dactylon* were recorded least (0.42 m^3) in scattered shrub while its maximum abundance was in low grassland (2.05 m^3). *Echinocloa* spp. and *Scirpus* spp. were minimum in scattered shrub whereas, *Echinocloa* spp. was abundant in low grassland while the *Scirpus* spp. was abundant in mosaic of several types. *Cyperus* spp. and *Bracharia* spp. was mostly abundant in scattered shrub and low grassland respectively. Whereas, abundance of *Sporobolus* spp. was maximum in wetland. In the grass savannah habitat, *Vetiveria zizanioides*

Table 8.13

Abundance of major species in volume m^3 for different vegetation types during monsoon

	WOOD	SCW	DST	SSH	SWS	SHS	GRS	LGR	MOS	WET
Bracharia reptans	0.7	1.13	1.77	0.15	0.24			2.54	0.73	0.04
Cynodon dactylon	0.89	1.48	1.31	1.13	0.99	0.42	1.95	2.05		1.59
Cyperus spp.		0.66	1.38	1.57	0.7	0.44	0.47	0.47	0.78	0.21
Desmostachya bipinnata	8.62	1.33	5.19		43.71	9.54	51.71	7.14		
Dicanthium annulatum			0.14	0.09	0.15	0.44	0.32	2.35		
Eragrostis spp.		0.55	0.2	1.00	1.00					
Echinochloa spp.	2.32	6.81	7.73	0.65	3.04	7.05	3.00	14.54	11.28	1.25
Eriochloa spp.	0.14	0.07	0.56							0.83
Ipomoea aquatica					0.02			0.19	0.45	0.36
Lagera spp.										
Paspalum distichum			0.01					0.33		1.22
Pseudoraphis spp.										3.00
Paspaldium spp.			0.43					0.34		0.1
Panicum antidotale		0.05	0.11							
Sporobolus spp.		0.43	1.32	0.54	1.03		0.54	1.08	1.77	2.23
Setaria spp.		0.8	0.52		0.89					
Scirpus spp.			2.54	0.21	0.57	4.84	2.93	2.52	31.6	2.14
Trianthema spp.		0.03	0.05	0.16	0.16		0.12	2.59	3.44	0.26
Vetiveria zizanioides	.21		1.00		20.72		63.19	1.28		6.47
Iseilema laxum								0.06		

Table 8.14

Abundance of major species in volume m^3 for different vegetation types during winter

	WOOD	SCW	DST	SSH	SWS	SHS	GRS	LGR	MOS	WET
Bracharia reptans		0.27	0.23		0.04	0.20		0.17	1.55	0.12
Cynodon dactylon	2.92	1.26	2.05	0.61	1.84	0.2	1.85	2.05	3.31	0.19
Cyperus spp.		0.56	1.13	0.41	0.51		0.5	1.4	5.22	1.02
Desmostachya bipinnata	8.05	3	7.85		47.67	10.44	56.7	5.82		1.02
Dicanthium annulatum		0.32	1.01	0.37	1.27	1.24	0.37	4.89	9.02	0.10
Eragrostis spp.			0.32	0.26	0.56					
Echinochloa spp.	2.60	1.94	2.00	1.43	0.97	1.02	0.54	2.72	9.85	0.61
Eriochloa spp.		0.16	1.1		0.43		0.45	0.87		
Ipomoea aquatica								0.03		0.16
Lagera spp.	0.19	0.47	0.01		0.05			0.11		0.01
Paspalum distichum			0.08					0.14		1.67
Pseudoraphis spp.										1.84
Paspaldium spp.										1.68
Panicum antidotale										0.6
Sporobolus spp.		0.36	1.08	0.44	0.64	1.24	0.16	2.36	1	0.22
Setaria spp.			0.29		0.29					
Scirpus spp.			0.46		0.05		0.94	3.33	8.64	2.77
Trianthema spp.	1.23	0.06						0.09		
Vetiveria zizanioides	7.45		1.9		26.76		62.2	2.36		0.84
Iseilema laxum					0.05	1.08	0.15			

Table 8.15

Abundance of major species in volume m^3 for different vegetation type during summer

	WOOD	SCW	DST	SSH	SWS	SHS	GRS	LGR	MOS	WET
Bracharia reptans										
Cynodon dactylon	1.76	1.23	0.78		0.88	0.05	1.36	2.09	2.07	1.79
Cyperus spp.			0.29		0.06			0.36	0.69	0.43
Desmostachya bipinnata	4.99	4.25	5.2		24.33	4.92	30.17	3.87		
Dicanthium annulatum		0.14	1.70		1.86	1.76	0.57	2.24	2.2	0.28
Eragrostis spp.		0.4	0.23	0.09	0.18	0.63		0.34	1.1	
Echinochloa spp.			0.27	0.06	0.01			0.79	3.53	0.11
Eriochloa spp.			0.3					0.16		
Ipomoea aquatica										0.61
Lagera spp.	1.32	0.6	0.24		0.13			0.01		0.21
Paspalum distichum			0.13					0.07		5.05
Pseudoraphis spp.								0.5		3.08
Paspaldium spp.								0.03		0.35
Panicum antidotale										
Sporobolus spp.		0.57	0.6	0.11	0.16	0.54		2.01	2.01	6.71
Setaria spp.										
Scirpus spp.			0.15		0.05		0.50	0.87	3.52	6.05
Trianthema spp.										
Vetiveria zizanioides	2.64		0.14		6.26		21.2	0.93		7.17
Iseilema laxum		0.05	0.01		0.11	0.59		0.43	0.82	

and *Desmostachya bipinnata* was abundantly present. *Paspalum distichum* and *Dicanthium annulatum* was recorded maximum in wetland and low grassland respectively (Table 8.13).

Winter

During winter *Cynodon dactylon*, *Dicanthium annulatum*, *Echinocloa* spp., *Sporobolus* spp. and *Cyperus* spp. were recorded *in most habitats. The maximum abundance of Cynodon dactylon*, *Echinocloa* spp., *Dicanthium annulatum* and *Cyperus* spp. was recorded in mosaic of several types. *Sporobolus* spp. was present abundantly in low grassland habitat. Like monsoon *Vetiveria zizanioides* and *Desmostachya bipinnata* was recorded maximum in grass savannah habitat while maximum *Paspalum distichum* was recorded in wetland (Table 8.14).

Summer

During summer *Cynodon dactylon*, *Dicanthium annulatum*, *Eragrostis* spp. and *Sporobolus* spp. was recorded in most of the habitats. *Cynodon dactylon* and *Dicanthium annulatum* was abundantly seen in low grassland and mosaic of several types. *Eragrostis* spp. was recorded maximum in shrub savannah while *Sporobolus* spp. was found dominant in wetland. *Desmostachya bipinnata* and *Vetiveria zizanioides* were dominant~~ed~~ in grass savannah. Maximum *Paspalum distichum* was also recorded in wetland (Table 8.15).

8.3.10 Grazing pressure on different species

The grazing pressure on 20 major palatable species of grass and herbs was calculated, of these 16 were grazed in monsoon, 19 in winter and 17 in summer. Index lower than one was regarded to indicate low grazing pressure, higher index was proportionately regarded as indicative of greater grazing pressure.

Monsoon

The maximum grazing pressure during monsoon was noticed on *Paspalum distichum* in low grassland area. *Sporobolus* spp. had maximum pressure in all the habitats except in mosaic of several type where it was 1.66. The pressure on *Sporobolus* spp. was maximum in scrub woodland habitat where this particular species is less abundant. *Eragrostis* spp. too was found under high grazing pressure in scrub woodland and savannah woodland to scattered tree savannah habitats (Table 8.16). *Cyperus* spp. and *Echinocloa* spp. were under high pressure in grass savannah, mosaic of several types and wetland. The high grazing pressure may be due to the scarcity of these species. Similarly *Cynodon dactylon* basically a terrestrial species is under less pressure in the terrestrial area where it is more abundant while in the wetland the pressure on *Cynodon dactylon* is maximum. *Vetiveria zizanioides* and *Desmostachya bipinnata* which are abundantly present in savannah woodland to scattered tree savannah are under low grazing pressure.

Table 8.16

Grazing pressure index on different plant species during monsoon for different vegetation types

	WOOD	SCW	DST	SSH	SWS	SHS	GRS	LGR	MOS	WET
Bracharia reptans	0.96	2.77					1.77			
Cynodon dactylon	0.4	1.37	1.51	1.6		2.58	1.72		4.70	
Cyperus spp.	0.75	3.07	0.6	1.36		3.66	0.58	3.3	3.50	
Desmostachya bipinnata				0.27		0.08	0.58			
Dicanthium annulatum				4.71			1.47			
Eragrostis spp.	16.66			14.22						
Echinochloa spp.	0.83	0.77		2.57		4.16	1.11	3.3	3.14	
Eriochloa spp.		5.55								
Ipomoea aquatica										
Lagera spp.										
Paspalum distichum							33.33		1.31	
Pseudoraphis spp.									2.87	
Paspaldium spp.									3.57	
Panicum antidotale										
Sporobolus spp.	16.66	2.29	6.25	4.7		4.16	4.7	1.66	2.38	
Setaria spp.				2.5						
Scirpus spp.		1.35		1.06		4.16	2.94			
Trianthema spp.						2.0	0.58			
Vetiveria zizanioides				0.16						
Iseilema laxum										

Table 8.17

Grazing pressure index on different plant species during winter for different vegetation types

	WOOD	SCW	DST	SSH	SWS	SHS	GRS	LGR	MOS	WET
Bracharia reptans		3.84	7.69					33.37	3.03	14.28
Cynodon dactylon	0.88	1.41	1.14	1.32	1.27		2.24	1.44	1.51	14.28
Cyperus spp.		3.3	5.07	6.25	7.5		16.66	3.22	0.66	14.28
Desmostachya bipinnata	1.0	3.84	0.99		0.07	0.37	2	3.3		3.57
Dicanthium annulatum		16.66	1.72		1.6	3.03	16.6	1.18	1.51	
Eragrostis spp.				6.25	50					
Echinochloa spp.	.0	0.6	1.62	0.6	3.35	3.03	16.6	1.56	1.51	3.14
Eriochloa spp.			2.72		20			5.76		
Ipomoea aquatica										3.57
Lagera spp.			25					1.92		
Paspalum distichum								33.3		2.67
Pseudoraphis spp.										3.57
Paspaldium spp.										7.14
Panicum antidotale										7.14
Sporobolus spp.		16.6	5.5	6.25	5	2.0	16.66	1.81	3.03	3.57
Setaria spp.										
Scirpus spp.			5.5				4.16	2.48	1.51	1.42
Trianthema spp.								33.33		
Vetiveria zizanioides	.0		2.53		0.06			8.33		
Iseilema laxum						1.51	8.33	3.3		

Table 8.18

Grazing pressure index on different plant species during summer for different vegetation types

	WOOD	SCW	DST	SSH	SWS	SHS	GRS	LGR	MOS	WET
Bracharia reptans										
Cynodon dactylon	4	1.23	1.8		2.26	6.25	2.7	1.15	1.0	2.0
Cyperus spp.			11.11		10			0.41	3.03	4.76
Desmostachya bipinnata	4	1.65	2.72		0.67	0.66	0.75	2.37		
Dicanthium annulatum		16.66	2.00		1.36	1.13	3.0	1.61	3.03	7.14
Eragrostis spp.		1.81	5.07					16.6	3.03	
Echinochloa spp.			3.63					2.95	1.0	
Eriochloa spp.			25		10	3.03		3.52		
Ipomoea aquatica										2.28
Lagera spp.		0.6								3.57
Paspalum distichum			25					33.33		1.56
Pseudoraphis spp.								33.33		2.85
Paspaldium spp.								33.33		7.14
Panicum antidotale										
Sporobolus spp.		3.03	4.54			3.03		1.72	1.00	1.55
Setaria spp.										
Scirpus spp.			25				8.33	2.77	1.51	7.14
Trianthema spp.										
Vetiveria zizanioides					0.15		0.27	1.92		1.42
Iseilema laxum		16.66			9.42	2.0		4.7	3.03	

Winter

Paspalum distichum , *Trianthema* spp. and *Bracharia* spp. seem to be under high grazing pressure during winter in low grassland areas. Besides these, *Cynodon dactylon* , *Cyperus* spp., *Ipomoea* spp., *Pseudoraphis* spp., *Paspaldium* spp. and *Panicum* spp. are also under high grazing pressure in wetland. *Dicanthium annulatum* and *Sporobolus* spp. are under high pressure in scrub woodland and grass savannah than in other habitats. In both these habitat these species are less abundant . During winter unlike monsoon *Vetiveria zizanioides* and *Desmostachya bipinnata* are under high grazing pressure in low grassland areas (Table 8.17).

Summer

Eragrostis spp., *Paspalum distichum*, *Pseudoraphis* spp. and *Paspaldium* spp. being scarce in low grassland habitat, are under high grazing pressure there. *Dicanthium annulatum*, *Sporobolus* spp. and *Isolema* spp. are under high pressure in scrub woodland habitat. Maximum grazing pressure in dense to discontinuous thickets is on *Cyperus* spp., *Eriochloa* spp., *Sporobolus* spp. and *Scirpus* spp. As during monsoon *Vetiveria zizanioides* and *Desmostachya bipinnata* are not under much grazing pressure in any habitat (Table 8.18).

8.4 Discussion

The present study indicates that maximum richness and diversity of plant species in most habitats is in winter followed by monsoon while in summer the diversity index declines in almost all habitat types. Habitat wise comparison shows that LGR and MOS offer maximum diversity (overall average for all the seasons). Other habitat types having high diversity are WET, SCW and DST. Low diversity habitats are SSH, SWS and GRS. It becomes easier, therefore, to understand why grazing was maximum in MOS and LGR during winter and monsoon. The reasons for higher grazing intensity also in WET during summer is obvious - the wetlands get almost dried up during summer but still retain comparatively higher sub-soil moisture and hence grasses *Paspalum distichum*, *Sporobolus* spp., and *Panicum* spp. grow there. Apart from that, plant growth in most other habitats retards in summer and ungulates are attracted to WET habitat because of comparatively abundant food resources.

The area covered by palatable species showed the variation in different seasons for different vegetation type. The only habitat which did not show any variation was shrub savannah where the grazing intensity was less due to the abundance of unpalatable species. Though this habitat is used for shelter, it is hardly used as a grazing land by ungulates except few Blackbuck which were seen grazing in the open patches. The maximum area covered by vegetation during monsoon and summer was in grass savannah habitat where the two major perennial grasses, namely *Vetiveria zizanioides* and *Desmostachya bipinnata* are abundant ~~thickly populated~~. In summer the wetland exceeds the grass savannah habitat in the percentage covered when most of the aquatic area dried up and the whole area is thickly carpeted with *Paspalum distichum*, *Panicum* sp. and *Sporobolus* spp.

The maximum volume occupied by unpalatable species was recorded in shrub savannah which is dominated by *Cassia tora* and *Achyranthes aspera*. Many of the present shrub savannah areas appeared to be covered previously by low grassland (Bholu pers. comm.) where most of the domestic cattle used to graze before the cattle grazing was stopped.

Over grazing will increase the exotic species (Milchunas *et al.* 1988) and the bush enchrochment (Jeffery 1961). The most frequent changes associated with cattle grazing have been reduction in perennial grass cover with a concomitant increase in the shrub component (Dodd and Brady 1986). The general mechanism of degradation has been studied by Perennou and Ramesh (1987) where they describe that the cutting of trees and over grazing lead the forest into shrub savannah. With this assumption it can be said that ~~at~~ once this shrub savannah area was ~~covered~~ previously ~~by~~ low grassland which was utilized by ungulates and when the pressure increase~~s~~d the habitat turned into shrub savannah resulting in larger number of unpalatable species which directly affect the density of the animal in that habitat when foraging is taken into consideration.

By looking at the data given in this chapter, it becomes clear ~~discernible~~ that the selective grazing in different habitat in each season follows the fluctuating abundance and scarcity of food resources in various habitats. Topography, soil and other ecological factors favour the growth of palatable plant species in different habitat types in each season and ungulate species keep moving from one to the other habitat type in accordance with the seasonal availability of their preferred food.

It is interesting to note that all ungulate species do not graze in one and the same habitat in any season. This is so because each species has its own order of preference and therefore grazes only in those habitats where they find found their preferred food. Chital for instance prefers *Cynodon dactylon*, *Sporobolus* spp., *Echinocloa* spp. and therefore grazes mostly in MOS throughout the year. But in summer season, when these grass species get dried up, Chital do not get enough of their most preferred food and also grazed in SCW and DST habitats. Similarly Sambar prefers *Paspalum distichum*, *Cyperus* spp., *Echinocloa* spp., *Ipomoea aquatica* and *Hydrilla* spp. and grazes in WET throughout the year because all these species are found there. But in summer mostly *Sporobolus* spp. and *Paspalum distichum* is found in WET while other preferred species disappear and hence Sambar also grazes in DST where it gets *Sporobolus* spp. as well as some other browse species to fulfill its nutritional requirements.

The same pattern of grazing in different habitats according to seasonal availability of palatable food is followed by all ungulate species. The season of acute scarcity of food in Keoladeo National Park is summer and that is the period when each ungulate species is found grazing in several habitat types to fulfill their food needs which cannot be done if they remain confirmed to only one or two habitat types. But growth of grasses and other food plants increases with the onset of monsoon and continues in winter till just before the start of the summer season and food resources during this period are found widespread in most habitats. Each ungulate species then gets freedom to choose the habitat with the widest area of its preferred food and therefore the species get selectively distributed in their preferred habitats. General scarcity of food in summer compels most ungulate species to look for food in several habitat types. As against this, comparative abundance of food during monsoon and winter allows each species to graze only in the habitats having the most preferred food plants.

Grazing pressure on plant species is directly related to their preference by ungulate species. Those plant species which are preferred by most ungulates are obviously under greater pressure while those eaten by only one or few ungulate species are under less pressure.

8.5 Summary

1) The diversity of plants in almost all the habitat was maximum during winter and monsoon season and lowest during summer season.

2) The area covered by palatable species varies from season to season as well from habitat type to another. There was, however, no seasonal variation in the area covered by palatable species in the shrub savannah habitat. The maximum area covered by the palatable species during monsoon and winter was in grass savannah, where *Vetiveria zizanioides* and *Desmostachya bipinnata* are dominant while in summer it was in the wetland.

3) The maximum volume occupied by palatable species throughout the year was recorded in grass savannah habitat.

4) The maximum area covered and volume occupied by unpalatable species was recorded in shrub savannah habitat which is dominated by *Cassia tora* and *Achyranthes aspera*.

5) The grazing intensity was more or less similar in all the habitat types except in low grassland, mosaic of several types and wetland where it was found higher.

6) Grazing pressure on different plant species was seen to vary in different seasons. Grazing pressure was inversely proportional to the abundance of the concerned species.

7) The trampling of vegetation by cattle was noticed mostly in low grassland and mosaic of several types.

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* Originals not referred

Appendix I

The botanical composition of monthly composite samples of Chital droppings in (a) 1987-88 and (b) 1988-89, based on the frequency of occurrence of epidermal fragments. N is the number of droppings pooled each months

(A)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Acacia nilotica	0.00	0.00	0.00	0.00	3.57	0.00	10.20	9.47	4.30	3.45	10.47	10.99
Acacia nilotica (Pod)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	2.30	1.16	0.00
Balanites roxburghii	0.00	0.00	0.00	0.00	0.00	0.00	3.06	0.00	0.00	0.00	0.00	0.00
Capparis sepiaria	0.00	0.00	0.00	0.00	3.57	0.00	9.18	7.37	9.68	8.05	18.60	13.19
Capparis decidua	0.00	0.00	0.00	0.00	0.00	0.00	3.06	3.16	0.00	4.60	8.14	3.30
Dichrostachys cinerea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.49	0.00
Kirgenelia reticulata	0.00	0.00	3.16	0.00	0.00	0.00	2.04	0.00	2.15	0.00	4.65	3.30
Prosopis juliflora	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.00	0.00	6.90	1.16	0.00
Salvadora persica	0.00	0.00	0.00	0.00	0.00	0.00	3.06	0.00	1.08	3.45	4.65	0.00
Zizyphus mauritiana	0.00	0.00	4.21	0.00	0.00	9.41	7.14	8.42	5.38	0.00	0.00	0.00
Bracharia reptans	4.55	5.38	0.00	0.00	3.57	3.53	0.00	0.00	0.00	4.60	2.33	0.00
Cynodon dactylon	34.09	30.11	27.37	22.35	15.48	23.53	19.39	25.26	30.11	25.29	9.30	19.78
Cyprus alopecuroides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Cyperus rotundus	5.68	0.00	5.26	11.76	3.57	4.71	4.08	5.26	4.30	0.00	0.00	5.49
Desmostachya bipinnata	0.00	3.23	0.00	3.53	0.00	11.76	3.06	2.11	6.45	2.30	9.30	4.40
Dicanthium annulatum	7.95	9.68	0.00	8.24	8.33	3.53	5.10	5.26	8.60	0.00	3.49	6.59
Echinochloa colonum	4.55	8.60	0.00	3.53	0.00	0.00	0.00	4.21	0.00	0.00	0.00	0.00
Eragrostis spp.	0.00	5.38	4.21	4.71	11.90	4.71	4.08	3.16	1.23	3.45	0.00	4.40
Eriochloa procera	3.41	0.00	7.37	0.00	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iseilema laxum	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00
Paspalum distichum	2.27	3.23	3.16	3.53	4.76	2.35	3.06	5.26	1.08	5.75	12.79	5.49
Scirpus tuberosus	2.27	3.23	4.21	3.53	0.00	4.71	2.04	2.11	5.38	5.75	0.00	2.20
Sporobolus helvolus	19.32	15.05	25.26	32.94	26.19	16.47	12.24	6.32	9.68	17.24	5.81	9.89
Vetiveria zizanioides	0.00	0.00	1.05	0.00	4.76	4.71	1.02	0.00	2.15	1.15	0.00	3.30
Coccinia cordifolia	0.00	1.08	2.11	0.00	2.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commelina forskalli	0.00	2.15	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commelina benghalensis	0.00	3.23	3.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyanotis axillaris	3.41	0.00	1.05	0.00	3.57	2.35	0.00	2.11	0.00	0.00	0.00	0.00
Ipomoea aquatica	0.00	2.15	1.05	0.00	0.00	3.53	0.00	2.11	0.00	0.00	0.00	0.00
Physalis spp.	3.41	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trianthema spp.	0.00	2.15	3.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vicia sativa	2.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Panicum antidotale	1.14	0.00	0.00	0.00	0.00	0.00	0.00	2.11	0.00	0.00	0.00	0.00
Unidentified	5.68	3.23	3.16	5.88	3.57	4.71	8.16	5.26	6.45	4.60	4.65	6.59
N	51.00	45.00	52.00	44.00	48.00	52.00	57.00	54.00	50.00	47.00	58.00	61.00

Note : Values are in percentage

Appendix I (contd)

(B)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Acacia nilotica	2.33	0.00	0.00	0.00	1.74	5.10	5.00	2.56	0.00	6.78	12.05	14.67
Acacia nilotica (Pod)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69	8.43	5.33
Acacia leucophloea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.02	1.33
Balanites roxburghii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.82	4.00
Capparis sepiaria	0.00	0.00	0.00	0.00	1.74	0.00	3.75	2.56	0.00	10.17	12.05	10.67
Capparis decidua	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.39	7.23	2.67
Kirgenlia reticulata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.61	0.00
Prosopis juliflora	2.33	0.00	0.00	0.00	0.00	8.16	0.00	0.00	0.00	1.69	6.02	0.00
Prosopis spicigera	0.00	0.00	0.00	0.00	0.00	2.04	0.00	0.00	0.00	1.69	1.20	0.00
Salvadora persica	0.00	0.00	0.00	0.00	0.00	4.08	3.75	0.00	0.00	0.00	1.20	0.00
Zizyphus mauritiana	0.00	0.00	0.00	0.00	0.00	0.00	12.50	2.56	0.00	0.00	0.00	0.00
Bracharia reptans	0.00	2.91	0.00	5.62	0.00	0.00	0.00	3.85	3.75	0.00	1.20	0.00
Cynodon dactylon	26.74	17.48	24.49	26.97	20.87	22.45	27.50	15.38	31.25	25.42	4.82	5.33
Cyperus alopecuroides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.08	0.00	0.00
Cyperus rotundus	1.16	6.80	8.16	4.49	13.91	5.10	0.00	12.82	0.00	0.00	0.00	4.00
Desmostachya bipinnata	0.00	0.00	0.00	0.00	0.00	13.27	8.75	3.85	3.75	0.00	8.43	0.00
Dicanthium annulatum	3.49	7.77	8.16	12.36	17.39	0.00	8.75	7.69	0.00	8.47	2.41	0.00
Echinocloa colonum	17.44	6.80	4.08	4.49	6.96	0.00	2.50	0.00	15.00	0.00	0.00	1.33
Eragrostis spp.	3.49	0.00	5.10	4.49	4.35	0.00	3.75	0.00	0.00	0.00	0.00	1.33
Eriochloa procera	0.00	2.91	2.04	0.00	3.48	0.00	2.50	0.00	1.25	0.00	0.00	0.00
Iseilema laxum	0.00	0.00	0.00	0.00	6.96	0.00	0.00	0.00	1.25	0.00	0.00	0.00
Paspalum distichum	5.81	16.50	5.10	0.00	0.00	3.06	0.00	0.00	7.50	0.00	6.02	0.00
Pseudoraphis spinescens	4.65	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Setaria spp.	0.00	0.00	4.08	1.12	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00
Scirpus tuberosus	0.00	7.77	5.10	6.74	0.00	0.00	0.00	6.41	7.50	8.47	2.41	4.00
Sporobolus helvolus	23.26	24.27	15.31	19.10	20.00	13.27	6.25	30.77	21.25	13.56	6.02	16.00
Vetiveria zizanioides	0.00	0.00	0.00	0.00	0.00	8.16	3.75	3.85	1.25	0.00	0.00	4.00
Coccinia cordifolia	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commelina forskalli	1.16	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	1.69	0.00	0.00
Commelina benghalensis	0.00	1.94	1.02	0.00	0.00	2.04	3.75	0.00	0.00	3.39	0.00	0.00
Cyanotis axillaris	2.33	1.94	4.08	2.25	0.00	3.06	1.25	0.00	0.00	0.00	0.00	0.00
Ipomoea aquatica	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Physalis spp.	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trianthema spp.	0.00	0.00	6.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Panicum antidotale	0.00	0.00	0.00	0.00	0.00	5.10	0.00	0.00	0.00	0.00	0.00	17.33
Unidentified	5.81	2.91	4.08	8.99	2.61	4.08	6.25	7.69	6.25	8.47	6.02	8.00
N	63.00	57.00	52.00	47.00	51.00	50.00	62.00	61.00	55.00	52.00	57.00	60.00

Note : Values are in percentage

Appendix II

The botanical compositions of monthly composite samples of Sambar droppings in (a) 1987-88 (b) 1988-89, based on the frequency of occurrence of epidermal fragments. N is the number of droppings pooled each month

(A)

	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Acacia nilotica	9.09	11.11	7.32	8.05	8.75	9.76	10.31	9.68	5.68	12.90	9.68	5.56
Acacia nilotica (Pod)	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00	0.00	4.30	0.00	0.00
Balanites roxburghii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.27	8.60	0.00	0.00
Capparis sepiaria	0.00	5.56	4.88	4.60	6.25	6.10	7.22	3.23	4.55	10.75	24.73	6.67
Capparis decidua	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.30	0.00	0.00
Prosopis juliflora	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	4.30	0.00
Cynodon dactylon	5.68	7.78	0.00	6.90	5.00	0.00	4.12	4.30	3.41	7.53	5.38	5.56
Cyperus alopecuroides	0.00	2.22	3.66	0.00	6.25	2.44	0.00	0.00	3.41	0.00	0.00	0.00
Cyperus rotundus	0.00	10.00	9.76	0.00	3.75	0.00	12.37	5.38	4.55	1.08	0.00	3.33
Desmostachya bipinnata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.30	0.00	0.00
Dicanthium annulatum	3.41	3.33	1.22	4.60	0.00	0.00	0.00	0.00	0.00	0.00	5.38	0.00
Echinochloa colonum	10.23	11.11	4.88	11.49	10.00	9.76	3.09	7.53	9.09	0.00	0.00	3.33
Eragrostis spp.	0.00	0.00	0.00	2.30	3.75	0.00	0.00	0.00	0.00	2.15	6.45	0.00
Eriochloa procera	5.68	0.00	6.10	4.60	0.00	2.44	0.00	0.00	0.00	0.00	0.00	0.00
Paspalum distichum	20.45	8.89	26.83	13.79	30.00	24.39	24.74	30.11	36.36	12.90	21.51	33.33
Pseudoraphis spinescens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	3.41	0.00	0.00	0.00
Scirpus tuberosus	9.09	3.33	6.10	6.90	6.25	9.76	14.43	7.53	2.27	0.00	0.00	3.33
Sporobolus helvolus	9.09	8.89	9.76	18.39	3.75	10.98	0.00	3.23	3.41	0.00	0.00	6.67
Ipomoea aquatica	6.82	13.33	0.00	4.60	0.00	4.88	6.19	4.30	6.82	8.60	3.23	0.00
Physalis spp.	0.00	0.00	0.00	0.00	0.00	4.88	0.00	0.00	0.00	0.00	0.00	0.00
Ceratophyllum demersum	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.56
Chara spp.	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14	0.00	0.00	0.00
Eleocharis plantaginea	0.00	3.33	0.00	0.00	0.00	0.00	3.09	5.38	0.00	0.00	0.00	7.78
Hydrilla verticillata	3.41	4.44	9.76	3.45	5.00	7.32	5.15	5.38	4.55	5.38	6.45	10.00
Najas minor	0.00	0.00	6.10	0.00	0.00	0.00	1.03	0.00	2.27	0.00	3.23	0.00
Nymphaea spp.	0.00	0.00	0.00	0.00	2.50	0.00	0.00	3.23	0.00	2.15	0.00	0.00
Nymphoides indicum	0.00	1.11	0.00	0.00	3.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Panicum antidotale	9.09	1.11	0.00	4.60	0.00	0.00	1.03	2.15	0.00	5.38	4.30	0.00
Potamogeton crispus	1.14	0.00	0.00	0.00	0.00	0.00	2.06	0.00	0.00	0.00	0.00	0.00
Unidentified	4.55	4.44	3.66	5.75	5.00	6.10	5.15	5.38	6.82	6.45	5.38	8.89
N	11.00	9.00	12.00	15.00	8.00	9.00	14.00	12.00	13.00	15.00	14.00	12.00

Note : Values are in percentage

Appendix II (contd)

(B)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Acacia nilotica	9.41	8.00	5.95	10.31	12.37	3.85	13.33	5.56	18.68	16.84	13.85	15.38
Acacia nilotica (Pod)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.85	2.20
Balanites roxburghii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.85	4.40
Capparis sepiaria	5.88	3.00	0.00	4.12	5.15	0.00	0.00	0.00	7.69	9.47	10.00	19.78
Prosopis juliflora	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00
Bracharia reptans	0.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.00	0.77	0.00
Cynodon dactylon	5.88	0.00	3.57	0.00	2.06	0.00	0.00	0.00	0.00	4.21	3.85	0.00
Cyperus alopecuroides	0.00	7.00	0.00	0.00	9.28	6.73	7.78	5.56	10.99	15.79	0.00	1.10
Cyperus rotundus	8.24	7.00	4.76	5.15	8.25	7.69	8.89	5.56	3.30	8.42	3.85	1.10
Dicanthium annulatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54	3.30
Echinochloa colonum	0.00	0.00	8.33	5.15	9.28	11.54	6.67	2.22	8.79	16.84	5.38	0.00
Eriochloa procera	0.00	0.00	0.00	3.09	3.09	0.00	0.00	7.78	0.00	0.00	6.15	0.00
Paspalum distichum	28.24	28.00	35.71	28.87	24.74	32.69	31.11	37.78	28.57	8.42	23.08	13.19
Pseudoraphis spinescens	0.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.00	0.00	0.00
Scirpus tuberosus	5.88	8.00	0.00	4.12	0.00	7.69	5.56	0.00	0.00	0.00	0.00	5.49
Sporobolus helvolus	4.71	4.00	0.00	0.00	0.00	0.00	5.56	0.00	0.00	7.37	6.15	9.89
Ipomoea aquatica	12.94	13.00	15.48	13.40	8.25	9.62	5.56	13.33	5.49	4.21	3.08	7.69
Ceratophyllum demersum	0.00	1.00	0.00	0.00	0.00	1.92	0.00	0.00	0.00	0.00	0.00	0.00
Chara spp.	0.00	1.00	0.00	0.00	0.00	0.00	0.00	2.22	0.00	0.00	0.00	0.00
Eleocharis plantaginea	0.00	0.00	0.00	0.00	1.03	0.00	0.00	2.22	0.00	0.00	0.00	0.00
Hydrilla verticillata	8.24	8.00	5.95	0.00	1.03	0.96	0.00	1.11	6.59	3.16	3.85	0.00
Najas minor	0.00	0.00	0.00	0.00	2.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nymphea spp.	0.00	8.00	8.33	7.22	0.00	0.00	0.00	0.00	2.20	0.00	0.00	0.00
Panicum antidotale	4.71	0.00	5.95	13.40	9.28	12.50	0.00	5.56	3.30	0.00	6.15	9.89
Unidentified	5.88	4.00	5.95	5.15	4.12	4.81	0.89	11.11	4.40	5.26	3.08	6.59
N	15.00	14.00	13.00	11.00	10.00	12.00	15.00	14.00	12.00	14.00	15.00	12.00

Note : Values are in percentage

Appendix III

The botanical composition of monthly composite samples of Blackbuck droppings in (a) 1987-88 (b) 1988-89, based on the frequency of occurrence of epidermal fragments. N is the number of droppings pooled each month

(A)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Bracharia reptans	5.68	3.80	6.41	0.00	0.00	0.00	[illegible]	4.71	0.00	0.00	5.32	0.00
Cynodon dactylon	27.27	30.38	43.59	27.59	41.56	37.04	33.33	40.00	35.71	24.39	38.30	27.59
Cyperus rotundus	7.95	7.59	0.00	5.75	6.49	0.00	15.48	8.24	0.00	4.88	3.19	0.00
Desmostachya bipinnata	0.00	1.27	0.00	0.00	0.00	7.41	0.00	0.00	0.00	2.44	0.00	0.00
Dicanthium annulatum	9.09	7.59	3.85	13.79	0.00	6.17	10.71	8.24	16.67	34.15	4.26	19.54
Echinochloa colonum	4.55	12.66	6.41	0.00	7.79	3.70	0.00	0.00	0.00	0.00	0.00	0.00
Eragrostis spp.	9.09	0.00	6.41	4.60	9.09	4.94	3.57	0.00	5.95	7.32	6.38	0.00
Eriochloa procera	0.00	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iseilema laxum	2.27	3.80	6.41	5.75	0.00	3.70	5.95	3.53	4.76	4.88	3.19	0.00
Paspalum distichum	4.55	3.80	2.56	3.45	5.19	0.00	2.38	5.88	3.57	3.66	18.09	20.69
Setaria spp.	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	3.57	0.00	0.00	0.00
Scirpus tuberosus	0.00	0.00	5.13	3.45	3.90	0.00	0.00	5.88	5.95	6.10	3.19	4.60
Sporobolus helvolus	18.18	22.78	14.10	25.29	12.99	28.40	21.43	17.65	15.48	6.10	14.89	22.99
Vetiveria zizanioides	0.00	0.00	0.00	0.00	2.60	3.70	0.00	0.00	0.00	0.00	0.00	0.00
Panicum antidotale	3.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unidentified	7.95	6.33	5.13	10.34	6.49	4.94	7.14	5.88	8.33	6.10	3.19	4.60
N	18.00	17.00	16.00	16.00	15.00	16.00	15.00	17.00	17.00	18.00	16.00	15.00

(B)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Bracharia reptans	3.53	0.00	0.00	3.30	0.00	0.00	0.00	3.49	5.68	0.00	0.00	5.88
Cynodon dactylon	35.29	33.73	26.67	35.16	24.47	31.40	24.39	30.23	18.18	33.33	25.29	28.24
Cyperus rotundus	0.00	7.23	0.00	7.69	5.32	0.00	0.00	0.00	11.36	0.00	0.00	0.00
Desmostachya bipinnata	0.00	0.00	0.00	7.69	8.51	0.00	0.00	11.63	0.00	4.76	5.75	3.51
Dicanthium annulatum	11.76	12.05	18.89	10.99	25.53	19.77	16.59	11.63	5.68	9.52	4.60	8.24
Echinochloa colonum	9.41	6.02	3.33	0.00	8.51	4.65	2.44	0.00	17.05	5.95	2.30	0.00
Eragrostis spp.	0.00	0.00	0.00	0.00	0.00	0.00	3.66	0.00	5.68	5.95	5.75	3.53
Eriochloa procera	0.00	0.00	0.00	0.00	0.00	1.16	6.10	0.00	0.00	0.00	5.75	0.00
Iseilema laxum	0.00	6.02	3.33	0.00	0.00	5.81	0.00	10.47	5.68	5.95	0.00	3.53
Paspalum distichum	18.82	18.07	15.56	2.20	5.32	5.81	0.00	2.33	12.50	5.95	8.05	11.76
Setaria spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38	0.00	0.00
Scirpus tuberosus	0.00	0.00	0.00	5.49	0.00	0.00	0.00	3.49	0.00	5.95	0.00	1.18
Sporobolus helvolus	9.41	10.84	26.67	17.58	19.15	25.58	9.76	17.44	13.64	13.10	17.24	15.29
Vetiveria zizanioides	0.00	0.00	0.00	5.49	0.00	0.00	7.32	5.81	0.00	1.19	0.00	2.35
Panicum antidotale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.69	10.59
Unidentifeid	11.76	6.02	5.56	4.40	3.19	5.81	9.76	3.49	4.55	5.95	4.60	5.88
N	17.00	19.00	20.00	15.00	15.00	17.00	16.00	18.00	19.00	21.00	20.00	19.00

Note : Values are in percentage

Appendix IV

The botanical composition of monthly composite samples of Nilgai droppings in (a) 1987-88 (b) 1988-89, based on the frequency of occurrence of epidermal fragements. N is the number of droppings pooled each month

(A)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Acacia nilotica	8.64	6.59	6.19	5.15	5.38	9.41	19.35	14.02	16.22	18.95	22.47	14.74
Acacia nilotica (Pod)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74	0.00	5.26	0.00	4.21
Acacia leucophloea	0.00	1.10	0.00	0.00	2.15	2.35	1.08	0.00	0.00	3.16	0.00	0.00
Balanites roxburghii	0.00	0.00	4.12	0.00	0.00	0.00	0.00	0.00	0.00	3.16	0.00	0.00
Capparis sepiaria	3.70	3.30	5.15	2.06	2.15	3.53	5.38	14.02	7.21	8.42	5.62	8.42
Capparis decidua	0.00	5.49	0.00	3.09	2.15	3.53	3.23	4.67	2.70	0.00	2.25	3.16
Prosopis juliflora	1.23	1.10	0.00	0.00	0.00	2.35	0.00	4.67	0.00	3.16	8.99	3.16
Salvadora persica	2.47	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zizyphus mauritiana	0.00	0.00	0.00	0.00	0.00	0.00	3.23	9.35	0.00	0.00	0.00	0.00
Bracharia reptans	0.00	0.00	0.00	0.00	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cynodon dactylon	23.46	13.19	14.43	14.43	30.11	21.18	3.23	7.48	9.91	5.26	5.62	8.42
Cyperus alopecuroides	0.00	2.20	4.12	0.00	0.00	1.18	0.00	0.00	0.00	0.00	2.25	0.00
Cyperus rotundus	0.00	0.00	0.00	0.00	0.00	0.00	3.21	3.74	3.60	1.05	0.00	0.00
Desmostachya bipinnata	6.17	5.49	3.09	2.06	4.30	5.88	3.21	6.54	4.50	15.79	5.62	0.00
Dicanthium annulatum	8.64	9.89	6.19	7.22	0.00	5.88	4.30	0.00	0.00	0.00	0.00	7.37
Echinochloa colonum	0.00	5.49	2.06	4.12	4.30	3.53	0.00	0.00	2.70	0.00	0.00	0.00
Eragrostis spp.	3.70	3.30	4.12	7.22	5.38	0.00	3.23	0.00	0.00	2.11	0.00	0.00
Eriochloa procera	0.00	0.00	2.06	2.06	1.08	1.18	0.00	0.00	2.70	0.00	0.00	0.00
Iseilema laxum	0.00	0.00	0.00	0.00	0.00	1.18	0.00	0.00	0.00	0.00	0.00	0.00
Paspalum distichum	11.11	2.20	11.34	11.34	8.60	7.06	5.38	7.48	7.21	5.26	17.98	18.95
Pseudoraphis spinescens	1.23	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Setaria spp.	2.47	2.20	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scirpus tuberosus	14.81	6.59	2.06	3.09	5.38	0.00	5.38	4.67	7.21	3.16	0.00	5.26
Sporobolus helvolus	3.70	9.89	8.25	18.56	17.20	18.82	8.60	4.67	9.01	5.26	10.11	15.79
Vetiveria zizanioides	0.00	3.30	0.00	0.00	0.00	0.00	1.08	1.87	4.50	0.00	3.37	2.11
Calotropis procera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70	3.16	1.12	0.00
Commelina forskalli	0.00	3.30	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commelina benghalensis	0.00	0.00	2.06	0.00	0.00	1.18	2.15	0.00	0.00	0.00	0.00	0.00
Cyanotis axillaris	0.00	3.30	2.06	0.00	1.08	0.00	3.23	0.00	0.00	0.00	0.00	0.00
Ipomoea aquatica	0.00	2.20	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.16
Trianthema spp.	0.00	4.40	3.09	0.00	0.00	2.35	0.00	0.00	0.00	0.00	0.00	0.00
Vicia sativa	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eleocharis plantaginea	0.00	0.00	0.00	0.00	0.00	3.53	0.00	0.00	0.00	0.00	0.00	0.00
Panicum antidotale	2.47	0.00	0.00	3.09	3.23	0.00	1.08	0.00	0.00	2.11	0.00	0.00
Pennisetum typhoides	0.00	0.00	6.19	5.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sorghum vulgare	0.00	0.00	4.12	4.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Cicer arietinum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	4.21	0.00	0.00
Pisum sativum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60	0.00	0.00	0.00
Triticum aestivum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	5.26	8.99	0.00
Brassica campestris	0.00	0.00	0.00	0.00	0.00	0.00	7.53	6.54	0.00	0.00	0.00	0.00
Unidentified	6.17	5.49	5.15	6.19	4.30	5.88	7.53	6.54	7.21	5.26	5.62	5.26
N	42.00	45.00	51.00	44.00	51.00	50.00	55.00	53.00	57.00	59.00	69.00	68.00

Note : Values are in percentage

Appendix IV (contd)

(B)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Acacia nilotica	8.47	7.69	7.55	3.00	4.63	4.85	[illegible]	4.25	5.10	5.05	10.31	7.77
Acacia nilotica (Pod)	6.78	7.69	0.00	0.00	2.78	0.00	0.00	2.06	0.00	0.00	5.15	2.91
Acacia leucophloea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.09	0.00
Balanites roxburghii	2.54	6.59	7.55	0.00	2.78	0.00	2.83	0.00	5.10	0.00	0.00	3.88
Capparis sepiaria	6.78	2.20	2.83	5.00	7.41	2.91	2.83	5.15	5.10	5.05	9.28	11.65
Capparis decidua	1.69	0.00	1.89	0.00	0.00	0.00	1.89	3.09	3.06	0.00	0.00	0.00
Dichostrachys cinerea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	1.02	0.00	1.03	0.00
Prosopis juliflora	1.69	0.00	0.00	0.00	0.93	4.85	10.38	5.15	3.06	4.04	0.00	5.83
Salvadora persica	0.00	0.00	0.00	0.00	0.00	2.91	2.83	0.00	1.02	0.00	0.00	0.00
Zizyphus mauritiana	0.00	0.00	0.00	0.00	0.00	0.00	7.55	3.09	0.00	0.00	0.00	0.00
Bracharia reptans	0.00	0.00	0.00	0.00	1.85	0.00	0.00	0.00	1.02	0.00	0.00	0.00
Cynodon dactylon	9.32	8.79	12.26	23.00	11.11	14.56	6.60	7.22	11.22	10.10	6.19	4.85
Cyperus alopecuroides	0.00	0.00	0.00	0.00	0.00	2.91	0.00	0.00	5.10	5.05	0.00	7.77
Cyperus rotundus	0.00	3.30	6.60	0.00	1.85	7.77	0.00	0.00	4.08	0.00	0.00	0.00
Desmostachya bipinnata	0.00	0.00	0.00	12.00	18.52	11.65	4.72	15.46	10.20	7.07	8.25	1.94
Dicanthium annulatum	5.08	10.99	8.49	0.00	0.00	0.00	7.55	5.15	4.08	4.04	5.15	4.85
Echinochloa colonum	7.63	0.00	2.83	0.00	0.00	0.00	0.00	2.06	8.16	7.07	0.00	0.00
Eragrostis spp.	0.00	0.00	0.00	7.00	7.41	0.00	0.00	3.09	0.00	0.00	0.00	0.00
Eriochloa procera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.03	0.00	0.00
Paspalum distichum	13.56	28.57	16.04	5.00	13.89	17.48	16.98	5.15	8.16	7.07	12.37	15.53
Setaria spp.	4.24	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.00
Scirpus tuberosus	0.00	0.00	0.00	15.00	0.00	0.00	2.83	9.28	0.00	4.04	3.09	0.00
Sporobolus helvolus	9.32	16.48	11.32	11.00	11.11	9.71	10.38	9.28	3.06	5.05	17.53	8.74
Vetiveria zizanioides	0.00	0.00	0.00	1.00	4.63	0.00	6.60	0.00	2.04	0.00	0.00	0.00
Calotropis procera	0.00	3.30	0.94	1.00	2.78	0.00	0.00	0.00	0.00	0.00	3.09	1.94
Commelina forskalli	0.00	0.00	0.00	0.00	2.78	0.97	0.00	0.00	0.00	0.00	0.00	0.00
Commelina benghalensis	0.00	0.00	0.00	0.00	0.93	0.97	0.00	0.00	0.00	0.00	0.00	0.00
Cyanotis axillaris	4.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ipomoea aquatica	4.24	0.00	5.66	0.00	1.85	0.00	0.00	3.09	0.00	0.00	0.00	2.91
Trianthema spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.91
Vicia sativa	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eleocharis plantaginea	0.00	0.00	0.00	0.00	0.00	6.80	0.00	0.00	0.00	0.00	0.00	0.00
Panicum antidotale	10.17	0.00	0.00	0.00	0.00	7.77	[illegible]	0.00	0.00	2.12	11.34	11.65
Pennisetum typhoides	0.00	0.00	5.66	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sorghum vulgare	0.00	0.00	4.72	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cicer arietinum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.08	5.05	0.00	0.00
Pisum sativum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.10	6.06	0.00	0.00
Triticum aestivum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.12	5.05	0.00	0.00
Brassica campestris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.22	0.00	0.00	0.00	0.00
Unidentified	3.39	4.40	5.66	3.00	2.78	3.88	2.83	5.15	4.08	5.05	4.12	4.85
N	62.00	70.00	71.00	67.00	68.00	74.00	77.00	71.00	60.00	65.00	64.00	58.00

Note : Values are in percentage

Appendix V

The botanical composition of monthly composite samples of Feral cattle droppings in (a) 1987-88 (b) 1988-89, based on the frequency of occurrence of epidermal fragments. N is the number of droppings pooled each month.

(A)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Acacia nilotica	0.00	0.00	0.00	0.00	0.00	0.00	3.09	0.00	0.00	0.00	0.00	0.00
Balanites roxburghii	0.00	0.00	0.00	0.00	0.00	0.00	2.06	0.00	0.00	0.00	0.00	0.00
Capparis sepiaria	0.00	0.00	0.00	0.00	0.00	0.00	5.15	0.00	0.00	0.00	0.00	0.00
Prosopis juliflora	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00
Salvadora persica	0.00	0.00	0.00	0.00	2.27	0.00	2.06	0.00	0.00	5.68	0.00	0.00
Bracharia reptans	0.00	0.00	3.53	3.23	0.00	0.00	0.00	0.00	0.00	0.00	4.49	0.00
Cynodon dactylon	21.95	18.00	28.23	29.03	31.82	25.45	28.87	13.64	16.85	12.36	8.98	21.35
Cyperus alopecuroides	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.21	4.49	0.00
Cyperus rotundus	3.66	0.00	2.35	4.30	5.68	2.12	8.25	3.64	0.00	3.21	3.37	5.62
Desmostachya bipinnata	6.10	4.00	0.00	0.00	7.95	2.12	12.37	0.00	22.47	17.22	17.90	0.00
Dicanthium annulatum	8.54	5.00	7.05	0.00	3.41	4.20	6.19	18.18	5.62	6.4	3.39	13.48
Echinochloa colnum	7.32	17.00	7.05	7.53	5.68	0.00	0.00	2.73	0.00	6.4	3.39	0.00
Eragroastis spp.	4.88	8.00	5.88	0.00	0.00	12.70	4.12	0.00	0.00	2.15	0.00	0.00
Eriochloa procera	0.00	0.00	0.00	1.08	2.27	2.25	0.00	0.00	0.00	0.00	0.00	0.00
Iseilema laxum	0.00	0.00	2.35	0.00	2.27	0.00	0.00	0.00	0.00	0.00	5.61	0.00
Paspalum distichum	0.00	5.00	7.05	7.53	5.68	6.38	3.09	27.27	11.24	13.97	16.85	24.72
Pseudoraphis spinescens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.73	0.00	3.21	2.24	0.00
Setaria spp.	4.88	5.00	0.00	0.00	2.27	0.00	0.00	2.73	0.00	0.00	0.00	0.00
Scirpus tuberosus	2.44	3.00	0.00	5.38	3.41	3.19	5.15	6.36	5.62	3.21	2.24	5.62
Sporobolus helvolus	31.71	15.00	11.76	22.58	18.18	17.02	0.00	7.27	8.99	5.37	5.81	23.60
Vetiveria zizanioides	0.00	3.00	2.35	3.23	0.00	0.00	10.31	7.27	16.85	7.95	11.25	0.00
Calotropis procera	0.00	0.00	0.00	0.00	0.00	3.19	0.00	1.82	2.25	2.27	0.00	0.00
Commelina forskalli	0.00	2.00	3.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commelina benghalensis	0.00	2.00	4.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyanotis axillaris	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ipomoea aquatica	0.00	0.00	3.53	7.53	2.27	3.19	0.00	0.00	0.00	0.00	0.00	0.00
Physalis spp.	0.00	0.00	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trianthema spp.	0.00	3.00	2.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vicia sativa	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eleocharis plantaginea	0.00	0.00	0.00	0.00	0.00	3.19	0.00	0.00	0.00	0.00	0.00	0.00
Panicum antidotale	0.00	0.00	0.00	3.23	0.00	4.25	0.00	0.00	0.00	2.15	2.24	0.00
Unidentified	7.32	5.00	7.06	5.38	6.82	10.66	8.25	6.36	10.11	5.68	7.8	5.62
N	80.00	76.00	74.00	65.00	62.00	70.00	74.00	77.00	91.00	78.00	84.00	75.00

Note : Values are in percentage

Appendix V (contd)

(B)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Acacia nilotica	0.00	0.00	0.00	0.00	0.00	0.00	2.06	0.00	0.00	0.00	0.00	0.00
Salvadora persica	0.00	1.11	0.00	0.00	0.00	0.00	3.09	0.00	0.00	0.00	4.12	0.00
Bracharia reptans	5.15	0.00	0.00	0.00	4.12	0.00	0.00	0.00	2.29	0.00	1.03	0.00
Cynodon dactylon	26.80	24.44	33.45	27.37	25.77	28.89	22.68	24.44	17.60	21.28	7.22	9.09
Cyperus alopecuroides	0.00	3.33	1.96	0.00	2.06	0.00	0.00	0.00	0.00	9.57	0.00	7.27
Cyperus rotundus	0.00	11.11	4.90	2.11	10.31	11.11	0.00	0.00	0.00	6.38	0.00	0.00
Desmostachya bipinnata	0.00	0.00	0.00	21.05	22.68	17.78	12.37	16.67	10.78	9.57	20.62	16.36
Dicanthium annulatum	5.15	7.78	16.66	10.53	0.00	4.44	12.37	3.33	10.78	0.00	5.15	8.18
Echinochloa colonum	5.15	3.33	0.00	1.05	0.00	0.00	0.00	0.00	5.80	6.38	0.00	0.00
Eragrostis spp.	1.03	0.00	0.00	3.16	0.00	0.00	0.00	0.00	5.80	5.32	0.00	0.00
Paspalum distichum	25.77	0.00	5.88	0.00	9.28	27.78	8.25	13.33	9.80	17.02	18.56	21.80
Pseudoraphis spinescens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	0.00	0.00	0.90
Setaria spp.	0.00	0.00	0.00	1.05	0.00	0.00	4.12	2.22	0.00	0.00	0.00	0.00
Scirpus tuberosus	6.19	8.89	0.00	4.21	0.00	0.00	5.15	8.89	5.80	2.13	0.00	3.60
Sporobolus helvolus	15.46	24.44	28.40	12.63	12.37	0.00	17.53	8.89	5.80	10.64	6.19	6.30
Vetiveria zizanioides	0.00	0.00	0.00	10.53	7.22	4.44	5.15	13.33	4.90	5.32	18.56	10.90
Calotropis procera	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00
Cyanotis axillaris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00
Ipomoea aquatica	3.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00
Trianthema spp.	0.00	5.56	0.00	0.00	0.00	0.00	0.00	0.00	1.96	0.00	0.00	0.00
Panicum antidotale	2.06	3.33	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	13.40	10.90
Unidentified	4.12	6.67	8.82	6.32	5.15	5.56	6.19	8.89	10.75	6.38	5.15	4.50
N	92.00	80.00	92.00	78.00	92.00	77.00	89.00	92.00	68.00	65.00	71.00	69.00

Note : Values are in precentage

Appendix VI

The botanical composition of monthly composite samples of Wild boar droppings in (a) 1987-88 (b) 1988-89, based on the frequency of occurrence of epidermal fragements. N is the number of droppings pooled each month

(A)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Prosopis juliflora	0.00	0.00	0.00	0.00	6.25	0.00	8.51	7.50	0.00	0.00	8.24	9.64
Zizyphus mauritiana	0.00	0.00	0.00	0.00	0.00	6.67	0.00	6.25	0.00	0.00	0.00	0.00
Bracharia reptans	0.00	5.33	5.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cynodon dactylon	0.00	8.00	7.45	8.79	2.50	0.00	5.32	0.00	0.00	5.00	0.00	2.41
Cyperus alopecuroides	9.64	6.67	9.57	7.69	8.75	6.67	8.51	7.50	5.00	3.75	0.00	6.02
Cyperus rotundus	40.96	32.00	20.21	35.16	36.25	26.67	28.72	18.75	18.75	30.00	30.50	28.92
Desmostachya bipinnata	0.00	0.00	0.00	0.00	0.00	4.00	5.32	0.00	5.00	6.25	5.88	2.41
Dicanthium annulatum	4.82	0.00	0.00	0.00	0.00	0.00	3.19	5.00	0.00	0.00	0.00	0.00
Echinochloa colonum	0.00	2.67	0.00	4.40	0.00	4.00	0.00	0.00	6.25	7.50	0.00	0.00
Eriochloa procera	0.00	0.00	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00
Paspalum distichum	3.61	0.00	8.51	7.69	0.00	0.00	0.00	8.75	7.50	0.00	7.06	7.23
Scirpus tuberosus	22.89	29.33	26.60	27.47	21.25	36.00	22.34	25.00	26.25	23.75	11.76	32.53
Sporobolus helvolus	0.00	0.00	4.26	0.00	0.00	4.00	3.19	6.25	5.00	0.00	3.53	0.00
Vetiveria zizanioides	0.00	0.00	2.13	0.00	0.00	0.00	5.32	0.00	0.00	0.00	5.88	0.00
Commelina forskalli	0.00	0.00	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commelina benghalensis	3.61	2.67	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ipomoea aquatica	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trianthema spp.	3.61	2.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eleocharis plantaginea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.75	10.00	0.00	0.00	0.00
Nymphoides indicum	0.00	0.00	0.00	0.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Panicum antidotale	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	3.75	0.00	0.00
Triticum aestivum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50	9.41	0.00
Cicer arietinum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.71	0.00
Unidentified	10.84	10.67	10.64	8.79	8.75	10.67	9.57	11.25	16.25	7.50	12.94	10.84
N	30.00	32.00	41.00	42.00	50.00	45.00	46.00	44.00	53.00	55.00	47.00	49.00

Note : Values are in percentage

Appendix VI (contd)

(B)

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Prosopis juliflora	14.12	0.00	8.14	0.00	5.68	7.84	7.29	9.88	10.53	12.90	0.00	0.00
Zizyphus mauritiana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	0.00	0.00
Cynodon dactylon	5.88	4.90	0.00	8.24	0.00	8.82	4.17	0.00	5.26	0.00	4.49	4.71
Cyperus alopecuroides	0.00	3.21	0.00	0.00	0.00	7.84	0.00	3.70	5.26	6.45	6.74	8.24
Cyperus rotundus	35.29	14.75	37.21	17.65	34.09	30.39	28.13	30.86	13.16	26.88	17.98	29.41
Desmostachya bipinnata	5.88	0.00	0.00	0.00	13.64	0.00	13.54	9.88	0.00	5.38	0.00	0.00
Dicanthium annulatum	0.00	6.56	0.00	4.71	0.00	0.00	4.17	0.00	0.00	0.00	0.00	0.00
Echinochloa colonum	0.00	6.56	0.00	4.71	0.00	6.86	0.00	8.64	0.00	0.00	7.87	0.00
Eriochloa procera	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.38	0.00	0.00
Paspalum distichum	5.88	0.00	0.00	14.12	0.00	0.00	5.21	0.00	0.00	0.00	2.25	8.24
Scirpus tuberosus	24.71	37.70	32.56	31.76	29.55	21.57	20.83	17.28	30.26	19.35	25.84	28.24
Sporobolus helvolus	0.00	0.00	3.49	0.00	2.27	7.84	2.08	4.94	6.58	0.00	6.74	0.00
Vetiveria zizanioides	0.00	0.00	0.00	0.00	5.68	0.00	7.29	0.00	0.00	0.00	6.74	3.53
Ipomoea aquatica	0.00	0.00	0.00	7.06	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00
Eleocharis plantaginea	0.00	13.11	0.00	0.00	0.00	0.00	0.00	6.17	6.58	0.00	0.00	0.00
Panicum antidotale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.37	8.24
Sorghum vulgare	0.00	0.00	4.65	5.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cicer arietinum	0.00	0.00	6.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Triticum aestivum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.21	10.75	7.87	0.00
Pisum sativum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.45	0.00	0.00
Unidentified	8.24	13.11	6.98	5.88	9.09	8.82	7.29	8.64	11.84	6.45	7.87	9.41
N	51.00	52.00	55.00	53.00	54.00	48.00	53.00	55.00	58.00	44.00	48.00	46.00

Note : Values are in percentage

Appendix VII

A list of common plants found in the Keoladeo National Park Bharatpur

Trees

1) *Acacia nilotica*
2) *Acacia leucophloea*
3) *Albizzia lebbeck*
4) *Azadirachta indica*
5) *Balanites roxburghii*
6) *Cassia fistula*
7) *Cordia dichotoma*
8) *Crataeva nurvala*
9) *Dalbergia sissoo*
10) *Delonix regia*
11) *Dichrostachys cinerea*
12) *Diospyros cordifolia*
13) *Ehretia aspera*
14) *Ficus benghalensis*
15) *Ficus glomerata*
16) *Ficus religiosa*
17) *Mitragyna parvifolia*
18) *Phoenix sylvestris*
19) *Prosopis juliflora*
20) *Prosopis spicigera*
21) *Randia dumatorium*
22) *Salvadora persica*
23) *Salvadora oleoides*
24) *Syzygium cumini*
25) *Tamarix aphylla*

26) *Tamarindus indica*

27) *Zizyphus mauritiana*

CLIMBERS

1) *Abrus precatorius*
2) *Asparagus racemosus*
3) *Cardiospermum halicacabum*
4) *Cayratia carnosa*
5) *Cocculus hirsutus*
6) *Coccinia cordifolia*
7) *Cryptostegia grandiflora*
8) *Cuscuta reflexa*
9) *Dregea volubilis*
10) *Ipomoea pestigridis*
11) *Ipomoea nil*
12) *Leptadaenia reticulata*
13) *Luffa acutangula*
14) *Momordica dioica*
15) *Melothria maderaspatana*
16) *Oxystelma secamone*
17) *Pergularia daemia*
18) *Rhynchosia minima*
19) *Tinospora cordifolia*

SHRUBS

1) *Adhatoda vasica*
2) *Capparis decidua*
3) *Capparis sepiaria*
4) *Clerodendrum phlomidis*
5) *Grewia tenax*

6) *Ipomoea carnea*

7) *Kirganelia reticulata*

8) *Lantana camara*

9) *Opuntia dillenii*

10) *Punica granatum*

11) *Vitex negundo*

12) *Zizyphus nummularia*

HERBS

1) *Abelmoschus ficulneus*

2) *Abutilon indicum*

3) *Acalypha indica*

4) *Acyranthes aspera*

5) *Aeschynomene indica*

6) *Ageratum conyzoides*

7) *Alhagi pseudalhagi*

8) *Alternanthera pungens*

9) *Alternanthera sessilis*

10) *Ammannia baccifera*

11) *Ammannia sengalensis*

12) *Amaranthus gracilis*

13) *Amaranthus spinosus*

14) *Amaranthus tricolor*

15) *Anagallis arvensis*

16) *Argemone mexicana*

17) *Bidens biternata*

18) *Blumea obliqua*

19) *Boerhavia diffusa*

20) *Caesulia axillaris*

21) *Cassia occidentallis*

22) *Cassia tora*

23) *Cassia pumila*

24) *Calotropis procera*

25) *Chenopodium murale*

26) *Chenopodium album*

27) *Cleome viscosa*

28) *Cochlearia cochlearioides*

29) *Coldenia procumbens*

30) *Commelina benghalensis*

31) *Commelina forskalii*

32) *Corchorus aestuans*

33) *Corchorus capsularis*

34) *Corchorus olitorius*

35) *Corchorus tridens*

36) *Crotalaria medicaginea*

37) *Cyanotis axillaris*

38) *Datura metal*

39) *Digera muricata*

40) *Eclipta prostrata*

41) *Eichhornia crassipes*

42) *Euphrobia hirta*

43) *Euphrobia hypercifolia*

44) *Evolvulus alsinoides*

45) *Gnaphalium indicum*

46) *Gnaphalium luteoalbum*

47) *Gomphrena celosioides*

48) *Grangea maderaspatana*

49) *Gynandropsis gynandra*

50) *Hydrolea zeylanica*

51) *Hygrophila polysperma*

52) *Indigofera cordifolia*

53) *Indigofera tinctoria*

54) *Indigofera trita*

55) *Jussiaea perennis*

56) *Laggera aurita*

57) *Leucaena leucocephala*

58) *Leucas urticaefolia*

59) *Lindernia crustacea*

60) *Lindernia parvifolia*

61) *Merremia emerginata*

62) *Monochoria vaginalis*

63) *Nicotiana plumbaginifolia*

64) *Nothosaerva brachiata*

65) *Oldenlandia corymbosa*

66) *Oldenlandia aspera*

67) *Pedalium murex*

68) *Peristrophe bicaliyculata*

69) *Phyla nodiflora*

70) *Phylanthus frternus*

71) *Phyllanthus simplex*

72) *Pluchea lanceolata*

73) *Plumbago zeyalanica*

74) *Polycarpon prostratum*

75) *Potentilla supina*

76) *Pulicaria crispa*

77) *Pupalia lappacea*

78) *Ruellia tuberosa*

79) *Rungia pectinata*

80) *Rumex dentatus*

81) *Salsola baryosma*

82) *Sesbania bispinosa*

83) *Sida rhombifolia*

84) *Sonchus arvensis*

85) *Solanum surattense*

86) *Suaeda fruticosa*

87) *Teramnus labialis*

88) *Tribulus terrestris*

89) *Trichosanthes cucumerina*

90) *Trianthema potulacastrum*

91) *Vernonia cinerea*

92) *Vicia sativa*

93) *Vicoa indica*

94) *Vigna trilobata*

95) *Withania somnifera*

96) *Zanthium strumarium*

GRASSES

1) *Cynodon dactylon*

2) *Dactyloctenium aegypticum*

3) *Desmostachya bipinnata*

4) *Dicanthium annulatum*

5) *Echinochloa colonum*

6) *Eragrostis* Spp.

7) *Eriochloa procera*

8) *Fimbristylis* Spp.

9) *Iseilema laxum*

10) *Oryza* Spp.

11) *Panicum antidotale*

12) *Paspalum distichum*

13) *Paspalidium punctatum*

14) *Pseudoraphis spinescens*

15) *Sporobolus helvolus*

16) *Vetiveria zizanioides*

AQUATIC

1) *Aponogeton natans*
2) *Astercantha longifolia*
3) *Ceratophyllum demersum*
4) *Cyperus alopecuroides*
5) *Cyperus rotundus*
6) *Eleocharis plantaginea*
7) *Hydrilla verticillata*
8) *Ipomoea aquatica*
9) *Lemna paucicostata*
10) *Marsilea Sp.*
11) *Najas minor*
12) *Neptunea oleraceae*
13) *Nymphaea nouchali*
14) *Nymphaea stellata*
15) *Nymphoides cristatum*
16) *Nymphoides indicum*
17) *Polygonnum limbatum*
18) *Polygonnum plebeium*
19) *Potamogeton crispus*
20) *Potamogeton nodosus*
21) *Sagittaria quayanensis*
22) *Sagittaria sagittifolia*
23) *Scirpus articulatus*
24) *Scirpus littoralis*
25) *Scirpus tuberosus*
26) *Spirodela polyrrhiza*
27) *Typha angustata*
28) *Wolffia Sp.*

Appendix VIII

A list of mammals occuring in the Keoladeo National Park, Bharatpur

1)	*Macaca mulatta*	: Rhesus macaque
2)	*Panthera pardus*	: Leopard
3)	*Felis chaus*	: Jungle cat
4)	*Felis viverrina*	: Fishing cat
5)	*Paradoxurus hermaphroditus*	: Common palm civet (Toddy cat)
6)	*Viverricula indica*	: Small Indian civet
7)	*Herpestes auropunctatus*	: Small Indian mongoose
8)	*Herpestes edwardsi*	: Common mongoose
9)	*Hyaena hyaena*	: Striped hyaena
10)	*Vulpes bengalensis*	: Indian fox
11)	*Canis aureus*	: Jackal
12)	*Lutra perspicillata*	: Smooth Indian otter
13)	*Suncus murinus*	: Musk shrew
14)	*Pteropus giganteus*	: Flying fox
15)	*Scotophilus heathi*	: Common yellow bat
16)	*Hipposideros fulvus*	: Bicoloured leaf-nosed bat
17)	*Funambulus pennanti*	: Five striped palm squirrel
18)	*Hystrix indica*	: Indian porcupine
19)	*Tatera indica*	: Indian gerbille
20)	*Bandicota bengalensis*	: Indian mole-rat
21)	*Vandeleuria oleracea*	: Longtailed tree mouse
22)	*Lepus nigricollis ruficaudatus*	: Rufoustailed hare
23)	*Boselaphus tragocamelus*	: Nilgai
24)	*Bos indicus*	: Feral cattle
25)	*Antilope cervicapra*	: Blackbuck
26)	*Axis axis*	: Chital
27)	*Cervus unicolor*	: Sambar
28)	*Sus scrofa*	: Indian wild boar

Appendix IX

A KEY TO THE IDENTIFICATION OF SELECTED MAJOR FOOD PLANTS

Hydrilla verticillata	:	Trichomes golden colour, not very long and the base contains multi cells.
Ipomoea aquatica	:	Dentate subsidary cells of stomata with no special cell arrangement, several ring like structure in the plant tissue.
Potamogeton crispus	:	Square crystals are abundant over the veins, tip of the cell are slightly larger.
Potamogeton indicus	:	Square crystals are less abundant, ring like structure present which are segmented.
Nymphea spp	:	Star shaped transparent trichomes in the plant tissues.
Nymphoides seed	:	Distinct attachment cells in tissues which are made up of thin walled cells tapering downwards.
Utricularia sp.	:	Trichomes are not abundant and usually occur on the leaf margins.
Najas minor	:	Short, one celled base trichomes, chain like structure present.

Chara sp. : Antheredeum round, archegonium oval, rose petal like structure present.

Ceratophyllum demersunm: Trichomes are having hooked tips and their bases are having single cells. Rectangular crystals cover the veins.

Vallisneria sp. : Trichomes are absent, neat rectangular cells present.

Brassica campestris : Pitted wavy textured trichomes are present, cells arranged in parallel rows.

Pisum aestivum : Paramecium like structure present, trichomes are not abundant and usually occur on leaf margin.

Cicer arietinum : Ligulate internally segmented trichomes having swollen bases that are usually small.

Triticum aestivum : Stomata very large and silica bodies are dumbbell shaped.

Oryza sativa : Silica cells resemble butterflies, small bristles all over the plant.

Sorghum vulgare : Stomates are mostly rounded but some are slightly peaked. Silica bodies are dumbbell shaped.

Pennisetum typhoides	:	Stomata are small and silica bodies are long bone-shaped.
Panicum antidotale	:	Silica cells in the coastal zone are bone shaped. Bristles are frequently present at the cell wall.
Paspalum distichum	:	Silica cells of coastal zone are peredominantly H shaped to nodular. Cell walls of inter coastl zone are unevenly dentate, pin like structure are common.
Echinocloa colonum	:	Silica cells in the coastal zone are square shaped, sometimes found in H shaped. Small trichomes are attached to the cell wall.
Sporobolus helvolus	:	Silica cells long in coastal and inter coastal zones, trichomes are papillate in shaped and stomates are small and round.
Eleocharis plantaginea	:	Silica cells are irregular cuboid shaped, stomata have peaked domes.
Bracharia reptans	:	Fragments have many short trichomes.
Vetiveria zizanioides	:	Stomata are small and have rounded domes. Fragements have prickels.

Desmostachya bipinnata : Silica cells in the coastal zones are rectangular shaped, bristles are also present at the margin, large ligulate trichomes sometimes present.

Dicanthium annulatum : Silica cells are dumbbell shaped, macro hair are frequently present.

Scirpus tuberosus : Stomata have peaked domes and look like triangular. Cells wall in the inter costal area senuous. Silica cells are dumbbell shaped.

Cynodon dactylon : Stomata are mostly rounded but some are slightly peaked, silica cells are small and round, usually in rows of two or three, trichomes are usually ligulate.

Eragrostis sp. : Stomata are long and elongated and are arranged in parallel. Silica cells are usually round and small but sometimes half moon shaped silica cells are also present, uniform cell structure.

Eriochloa procera : Silica are pin like shaped, stomata appear oval in shape. Trichomes are small.

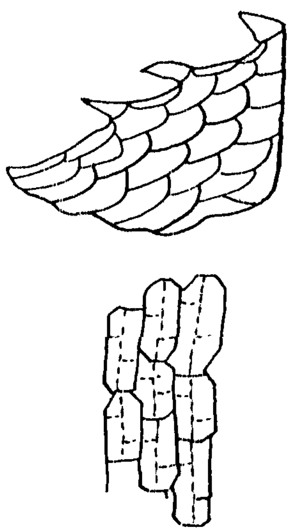
Iseilama laxum : Silica bodies are short, small dumbbells that look like bow ties. *Stomata are triangular in shaped.*

Cyperus rotundus	:	Silica bodies are dumbbell shaped with rounded ends. Stomates are small and round.
Echinochloa procera (Inflorescence)	:	Ribbon like structure present in parallel rows
Setaria sp.	:	Silica cells in costal zone bone-shaped. Long cells of intercostal zone are rectangular and sommetimes diamond shaped, micro hair present.
Paspaldium punctatum (Leaves)	:	Epidermal cells are having papillate protrusion. Silica bodies are short, small dumbbells that look like bow ties, stomates are long and elongated.
Paspaldium punctatum (Inflorescence)	:	Ribbon like structure present in paralel rows containing pits.
Trianthema portulocastrum	:	Trichomes are ligulate and with mucronate tips.
Cyanotis axillaris	:	Trichomes are flexible with a mucronate tip and 1 - celled base. Large hexagonal cell present.
Commelina forskalli	:	Two types of trichomes are present; one is ligulate segmented trichomes, the other is having hooked tips and their bases are having single cells.

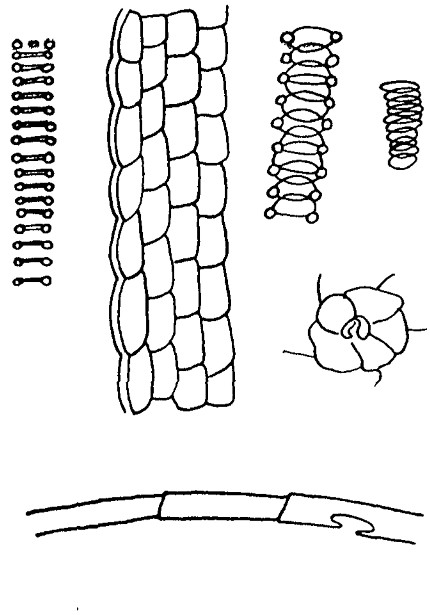
Commelina bengalhensis	:	Only one type of trichomes are present which is segmented and ligulate.
Dregia sp.	:	Trichomes are not abundant,druses are common.
Coccinia cordifolia	:	Short ligulate trichomes are present.
Vicia sativa	:	Neat rectangular cell, small mushroom like structure present in cluster.
Achyranthes aspera	:	Inter coastal cells are square and very small druses are present inside these cells,large segmented trichomes having thick swallon bases which are spiny.
Physalis minima	:	Lot of ring like structure present.
Merremia emerginata	:	Rod like trichomes are present.
Calatropis procera	:	Trichomes are branched, sqaure crystls are found over the veins.
Salvadora oleoides	:	Two types of trichomes present; one is branched to form a 'Y' and other forms 'T' shaped.
Salvadora persica	:	Only one type of trichomes is present i.e 'T' shaped trichomes.

Clerodendron phlomidis	:	Square and rectangular crystal are abundant, trichomes are small, ligulate and segmented.
Acacia nilotica	:	Trichomes are branched, dragon fly like structure present inside the cell, small to medium size crystals are abundant.
Prosopis juliflora	:	Ligulate internally segmented trichomes having swollen bases with three sided attachment cells. Small square crystals are present over the veins.
Capparis sepiaria	:	Trichomes are ligulate and segmented having two sided attachment cells.
Prosopis spicigera	:	Large ligulate segmented trichomes are present with six sided cell attachment.
Kirgenelia reticulata	:	Trichomes are small and segmented and some nipple like papillae are present. Small square crystals are abundant.
Zizyphus mauritiana	:	Trichomes unicellular flat and ribbon like which are curly and present in cluster.

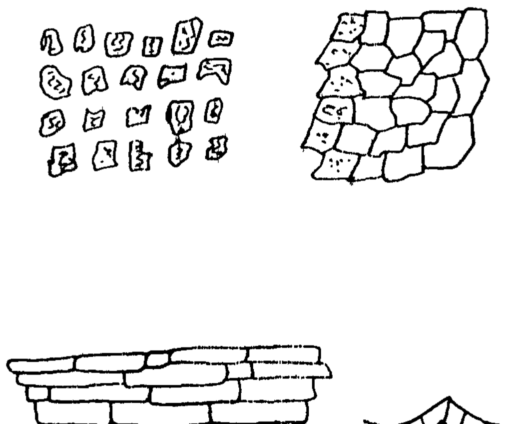
Acacia leucophloea	:	Short ligulate trichomes are present on leaf margin having a mucronate tips with four sided attachment cells.
Balanites roxburghi	:	Ligulate trichomes are present with six sided attachment cell. Medium size druses occur in tissues with angular cells.
Dichrostachys cinerea	:	Short ligulate trichomes are present on leaf margin. Small angular shaped crystals present on the veins.
Cassia tora	:	Fragments are without trichomes. Druses are present with small angular crystals over the vein.
Salvadora persica (Fruit)	:	Thin, sharp like spicules are present in cluster. Small grannules are abundant.
Acacia nilotica (Pod)	:	Long, thin, spicules are arranged parallel.
Cyperus alopecuroides (Leaves)	:	Stomata are round and small, silica bodies are short and circular in shape.
Cyperus alopecuroides (Inflorescence)	:	Small oval shaped cell tapering at one end and are present abundantly.



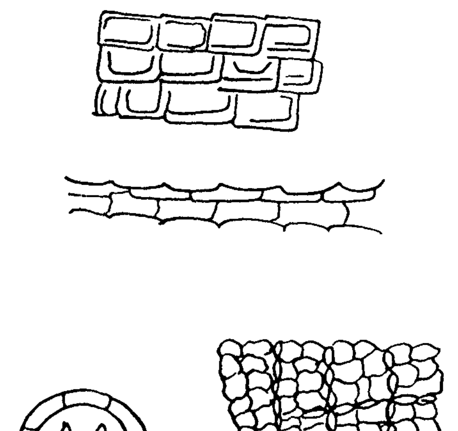
HYDRILLA VERTICILLATA



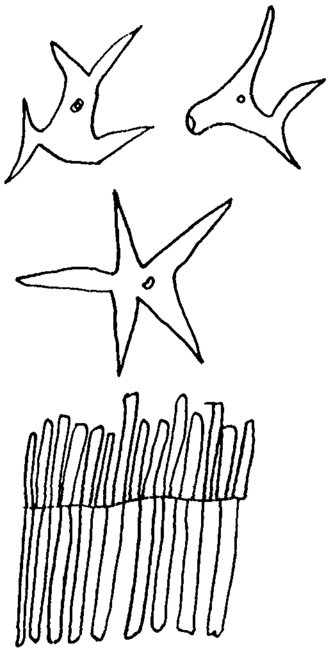
IPOMOEA AQUATICA



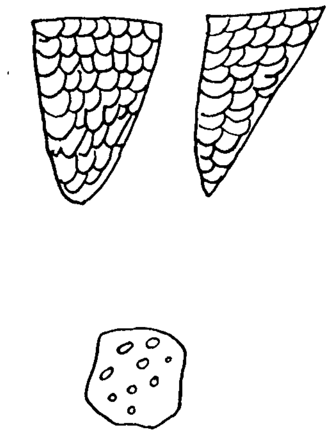
POTAMOGETON CRISPUS



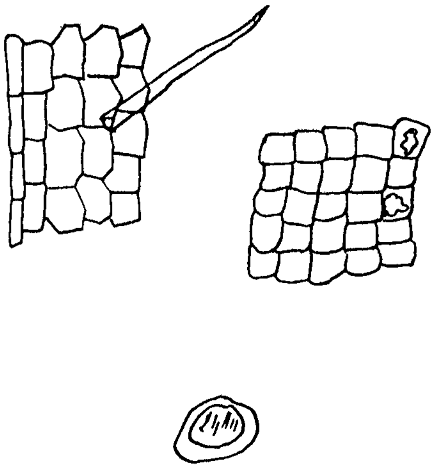
POTAMOGETON INDICUS



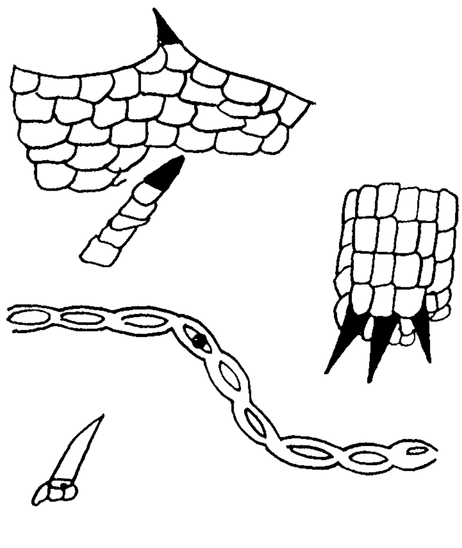
NYMPHEA



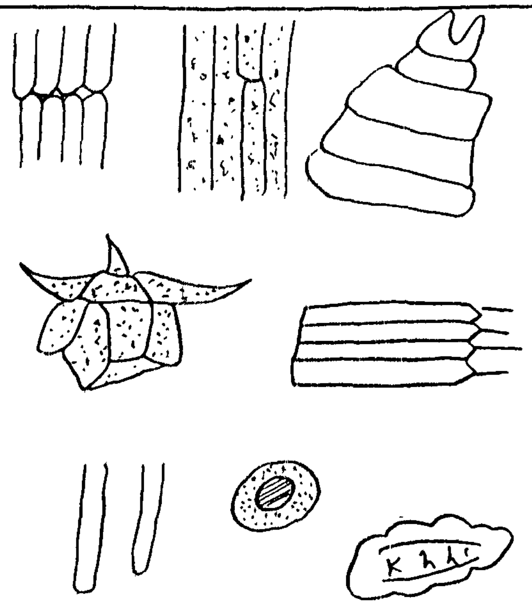
NYMPHOIDES (SEED)



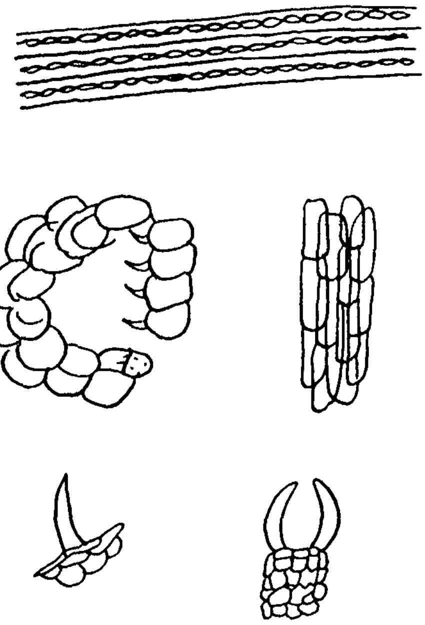
UTRICULARIA Sp.



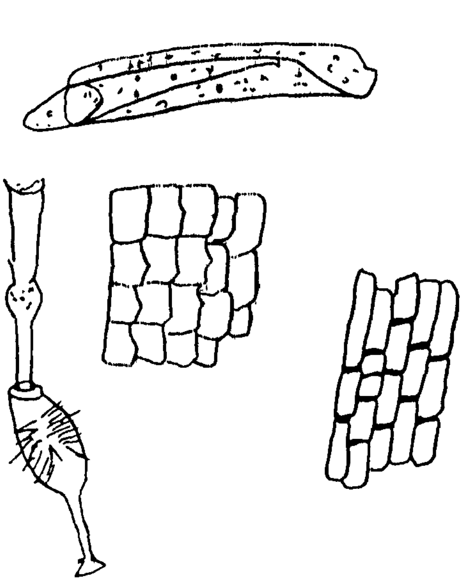
NAJAS MINOR



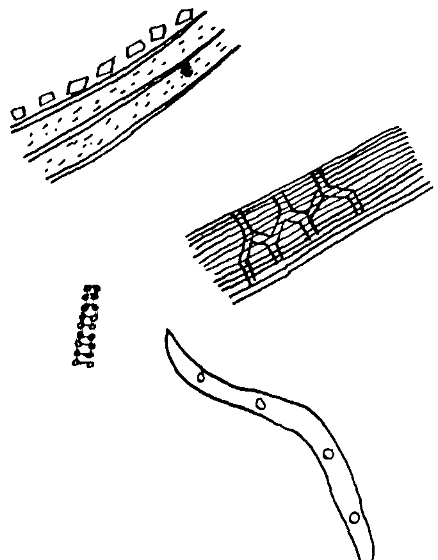
CHARA Sp.



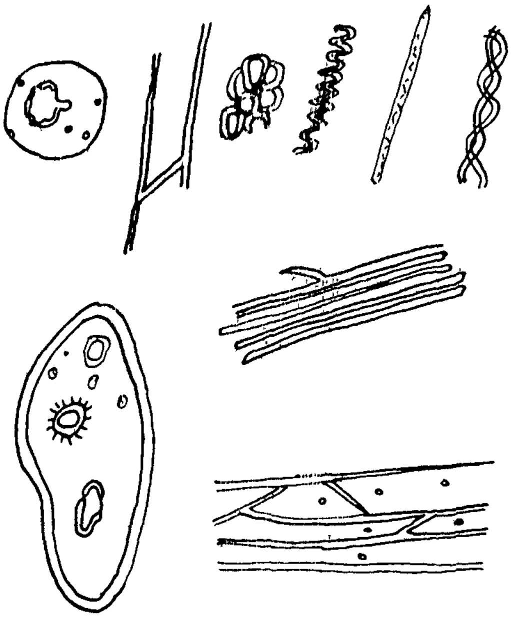
CERATOPHYLLUM DEMERSUM



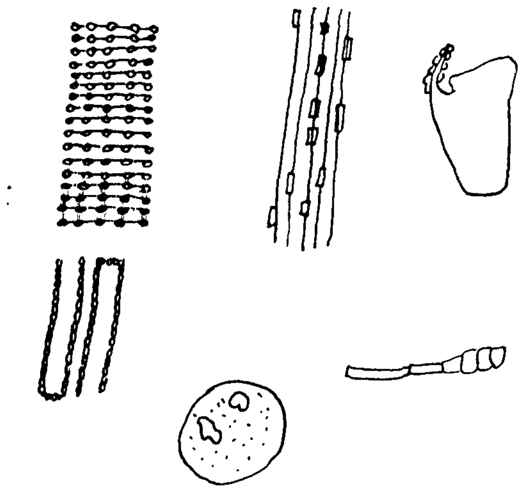
VALLISENERIA



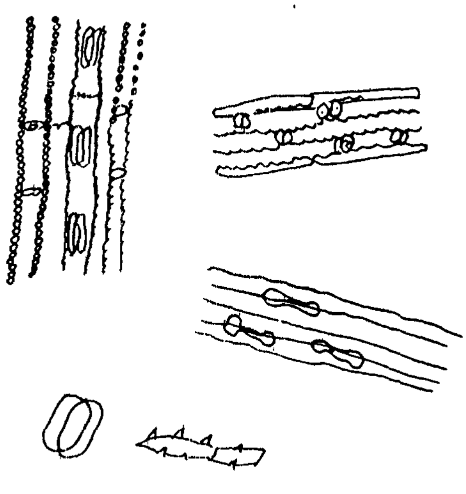
BRASSICA CAMPESTRIS (MUSTARD)



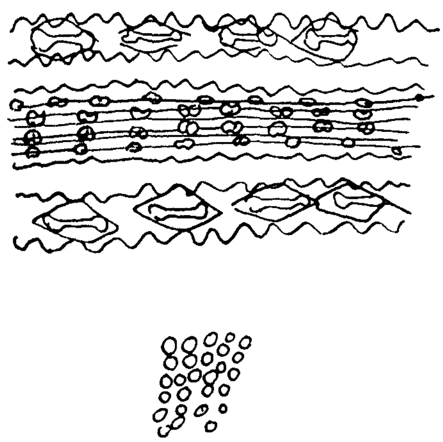
PISUM AESTIVUM (MATAR)



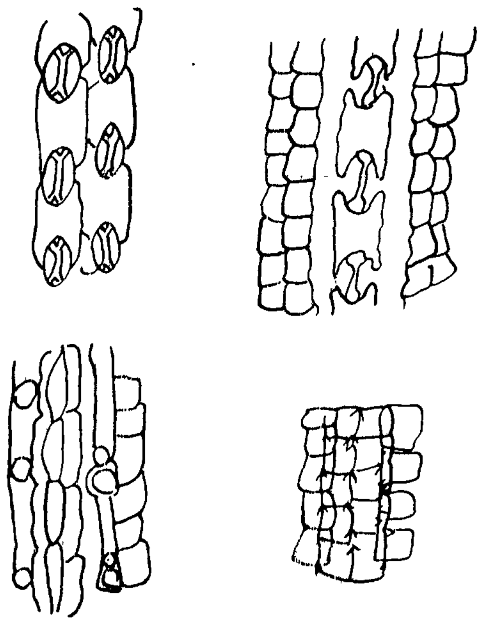
CICER ARIETINUM (CHANA)



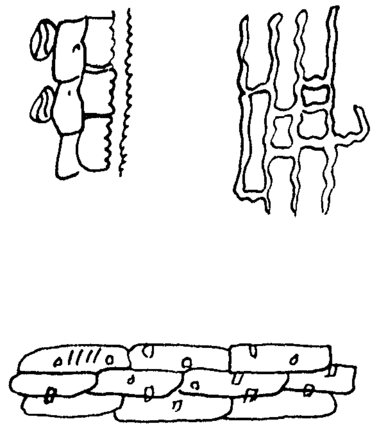
TRITICUM-AESTIVUM (WHEAT)



ORYZA SATIVA



SORGHUM VULGARE (JOWAR)



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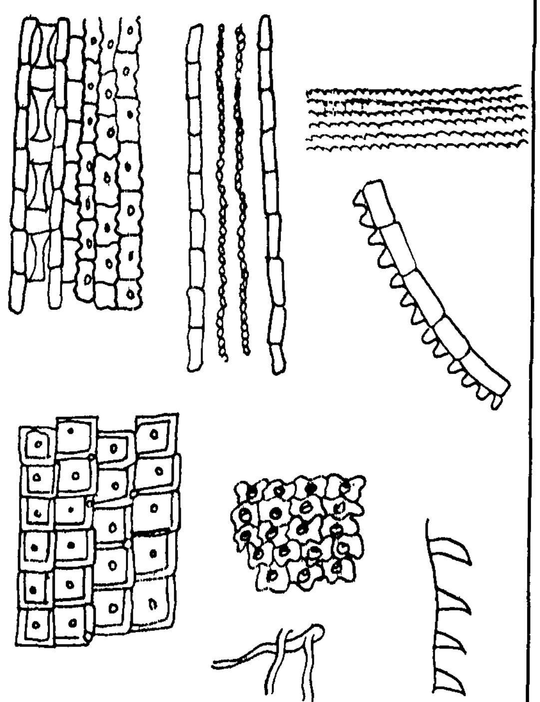

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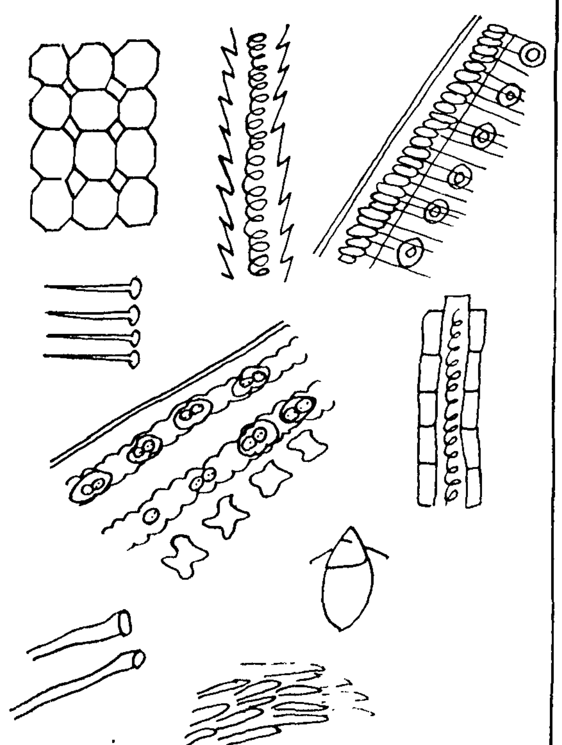

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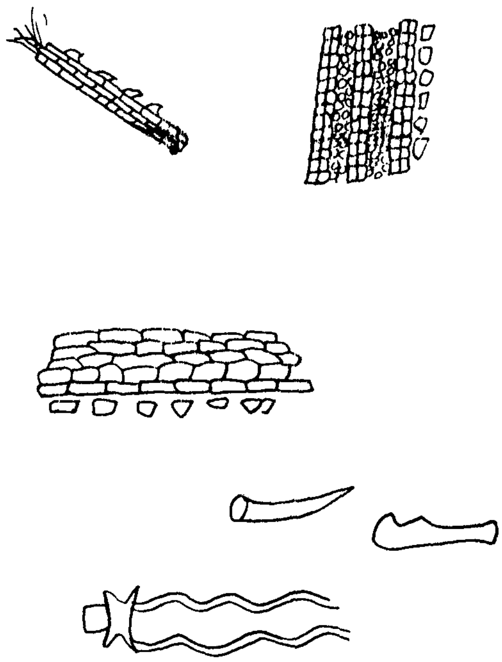
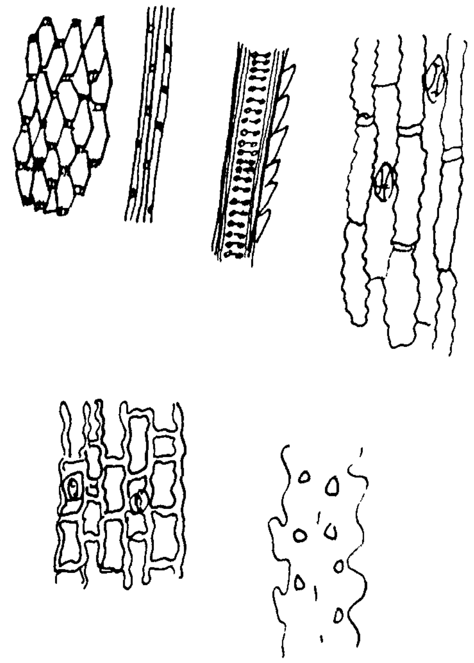


ECHINOCLOA COLONUM



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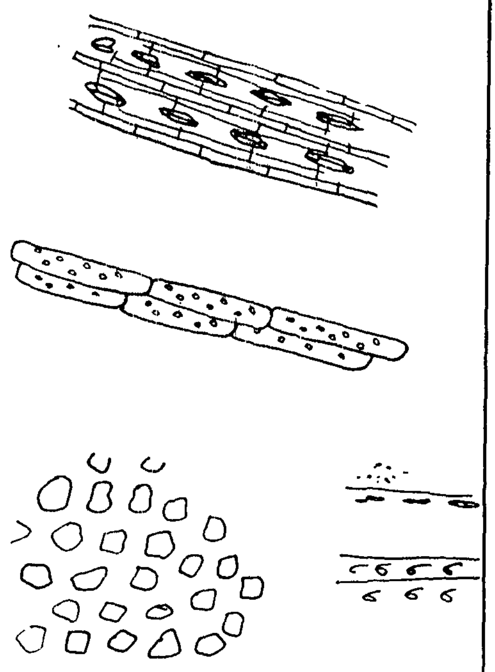
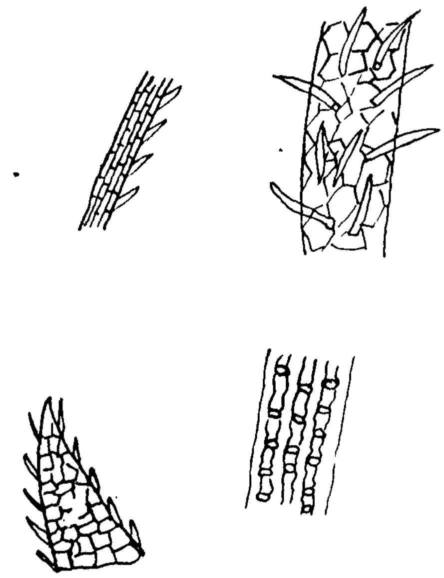
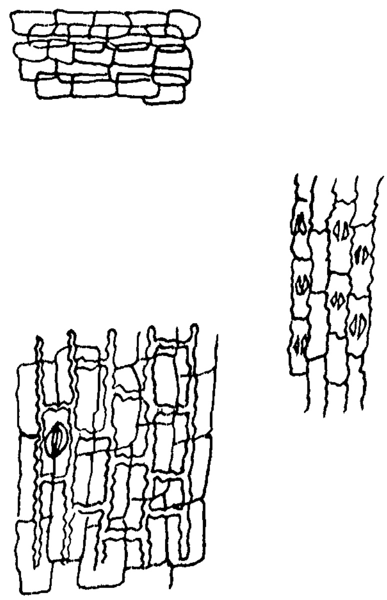


ELEOCHARIS PLANTAGINEA



BRACHARIA REPTANS



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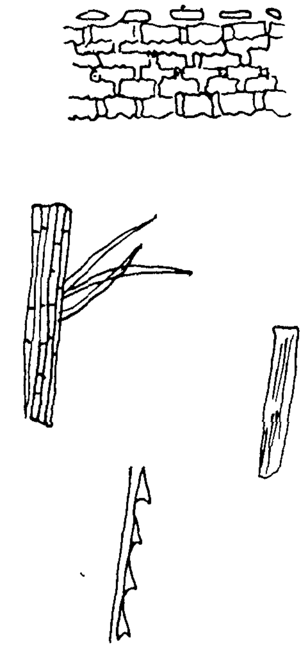

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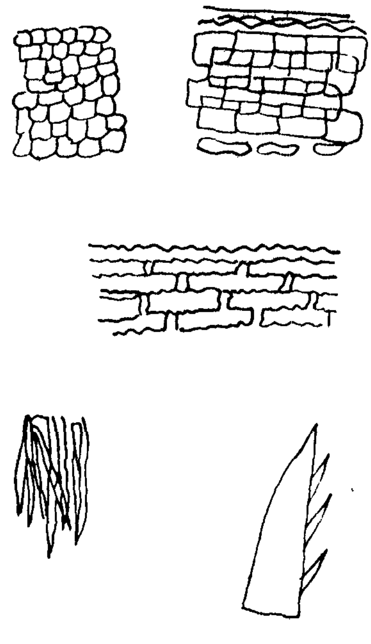
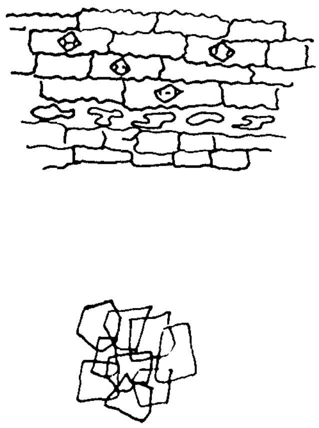


DICANTHIUM-ANNULATUM



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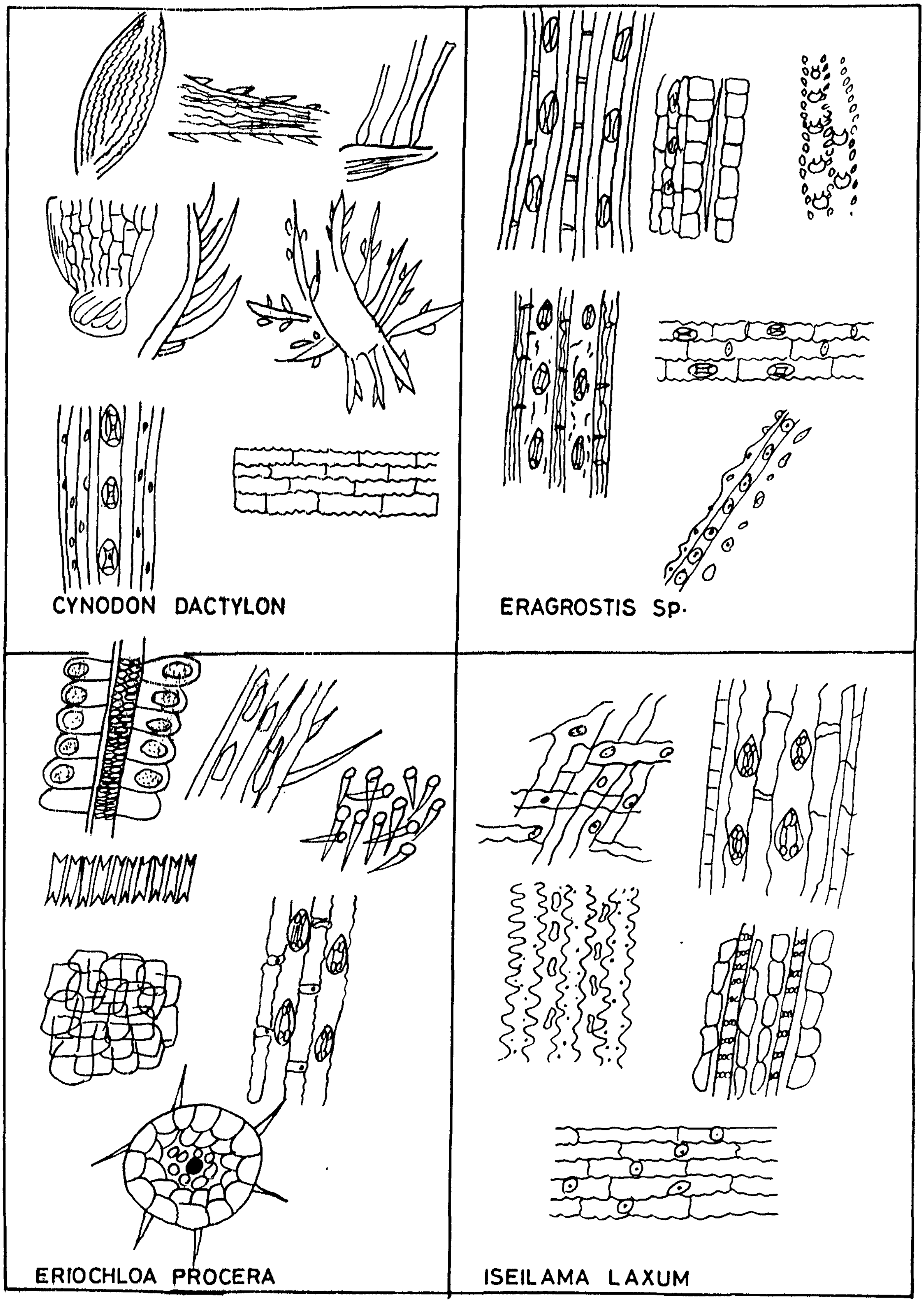
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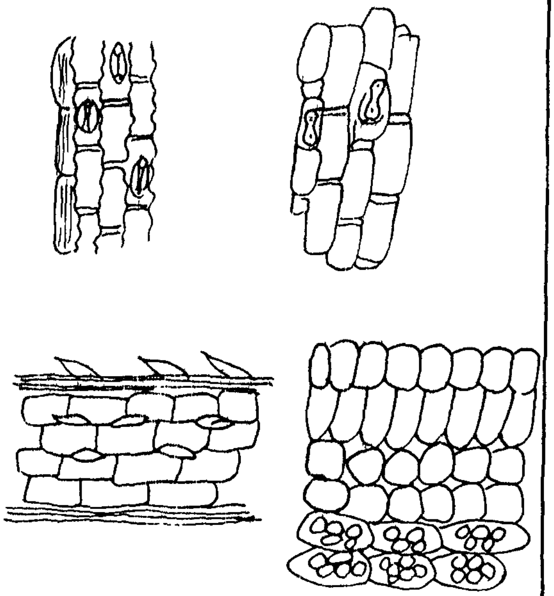
ERAGROSTIS Sp.
ERIOCHLOA PROCERA
ISEILAMA LAXUM



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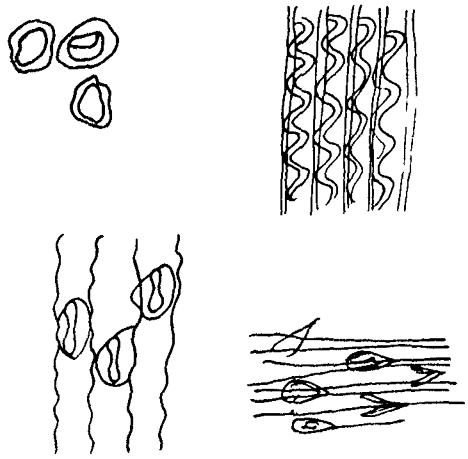
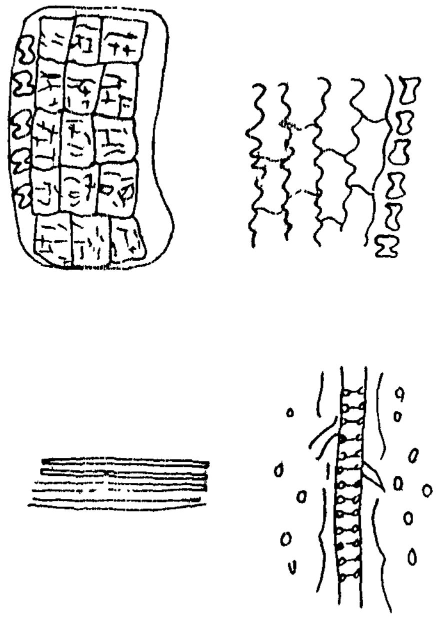
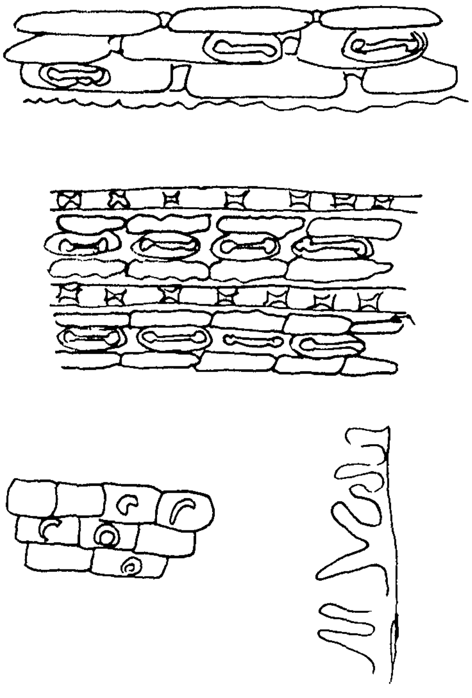


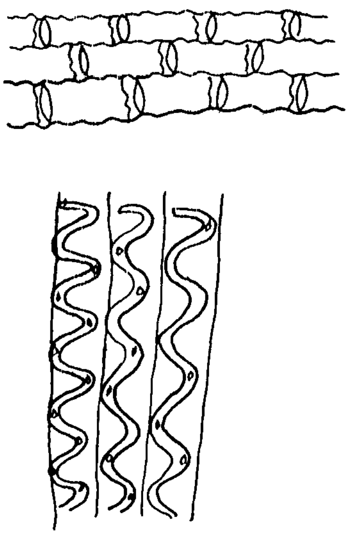
ECHINOCHLOA PROCERA (INFLORESCENCE)



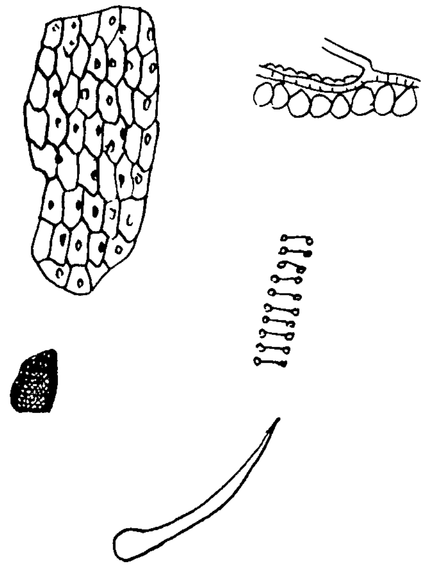
SETARIA Sp.



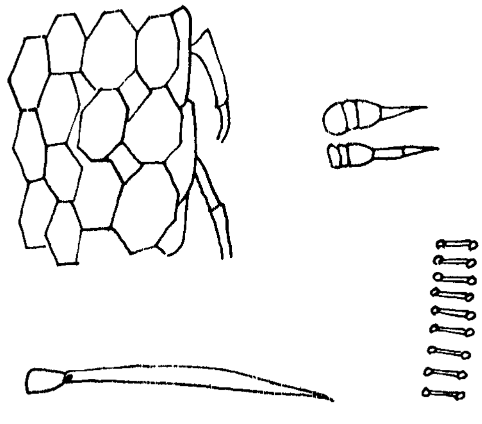
PASPALDIUM PUNCTATUM , (LEAVES)



PASPALDIUM PUNCTATUM (Inflorescence)



TRIANTHEMA PORTULACASTRUM



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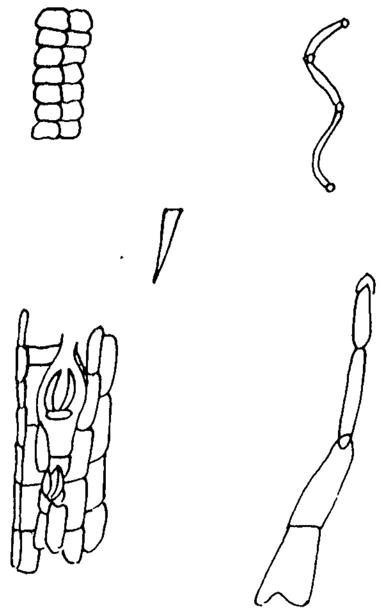

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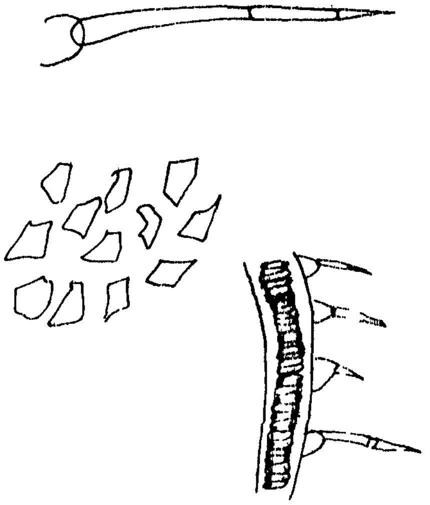
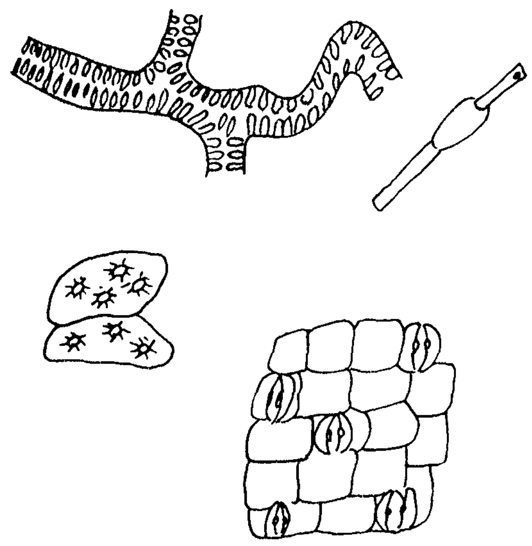
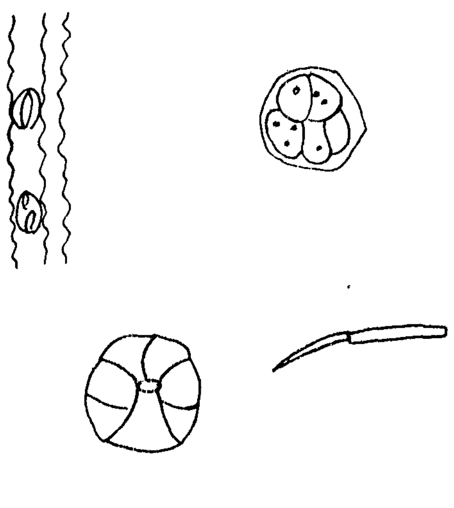


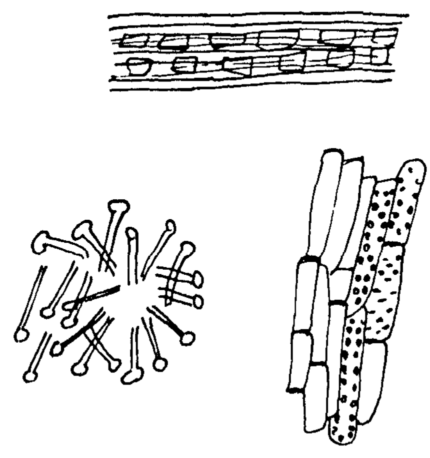
COMMELINA BENGHALENSIS



DREGIA Sp.

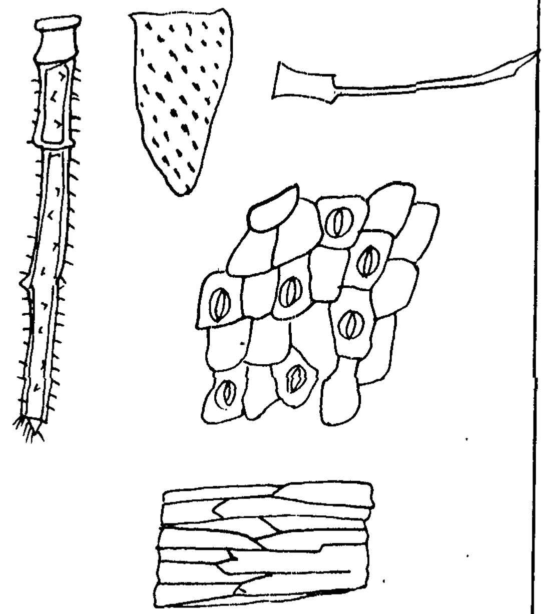


COCCINIA CORDIFOLIA

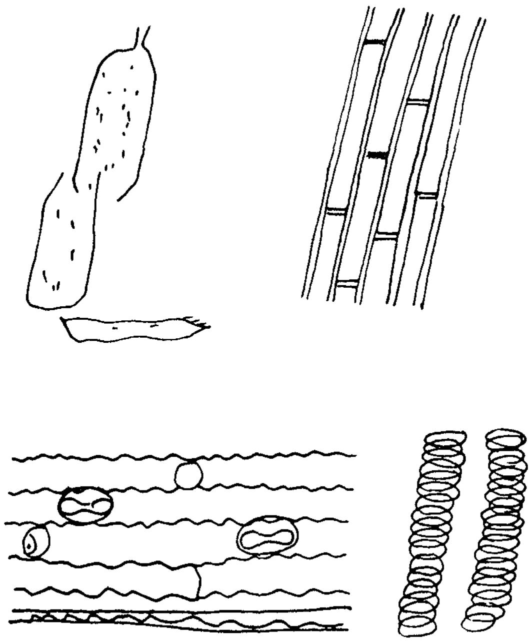


VICIA SATIVA

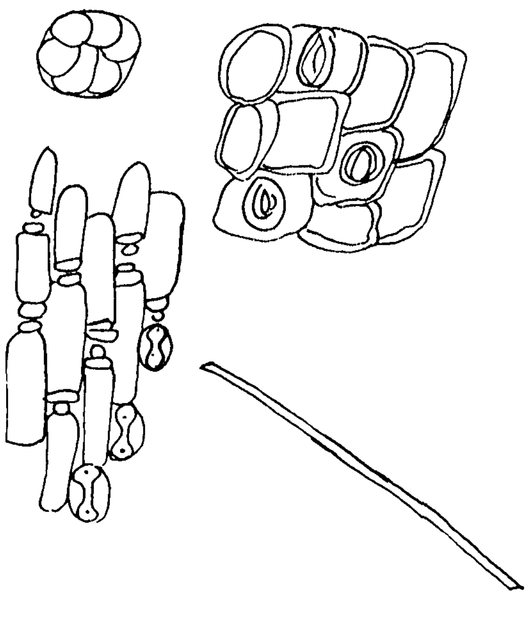
GATT



ACHYRANTHES ASPERA



PHYSALIS MINIMA



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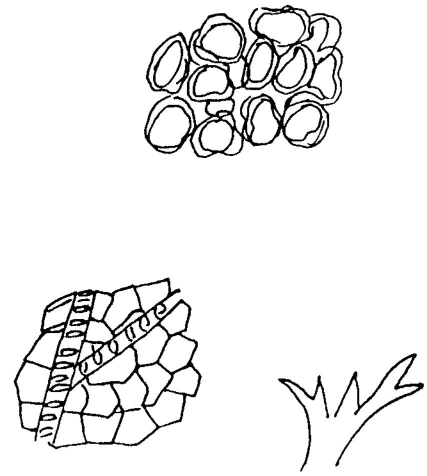

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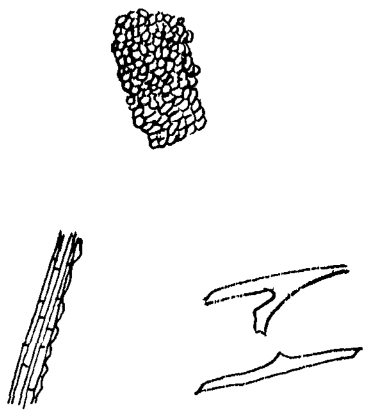

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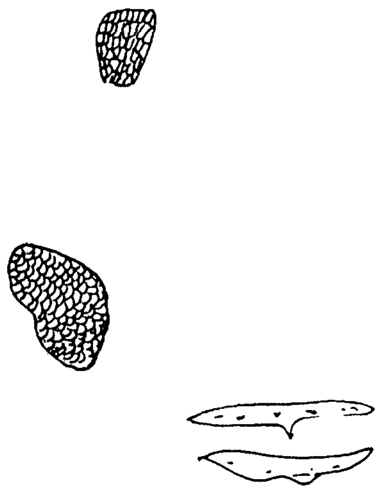
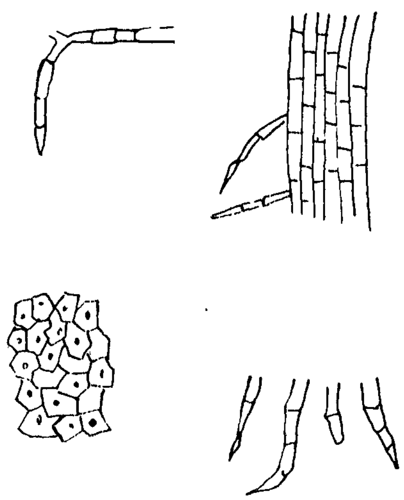
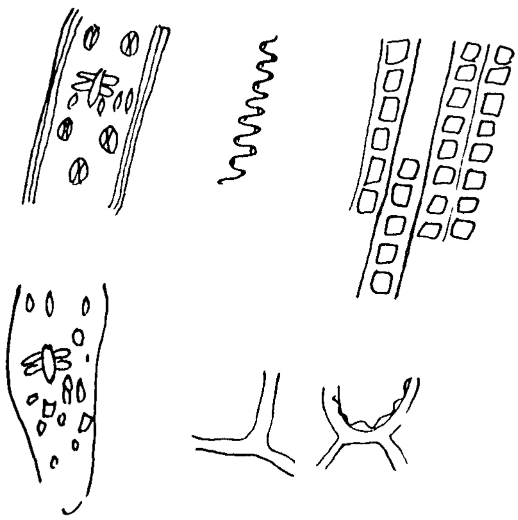


SALVADORA PERSICA



CLERODENDRON PHLOMIDIS



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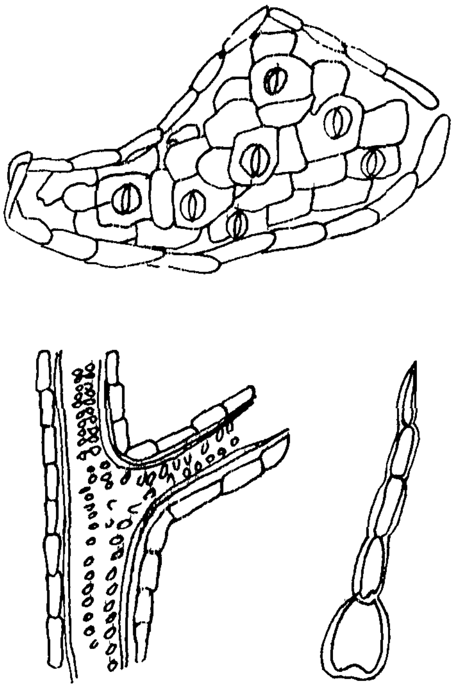
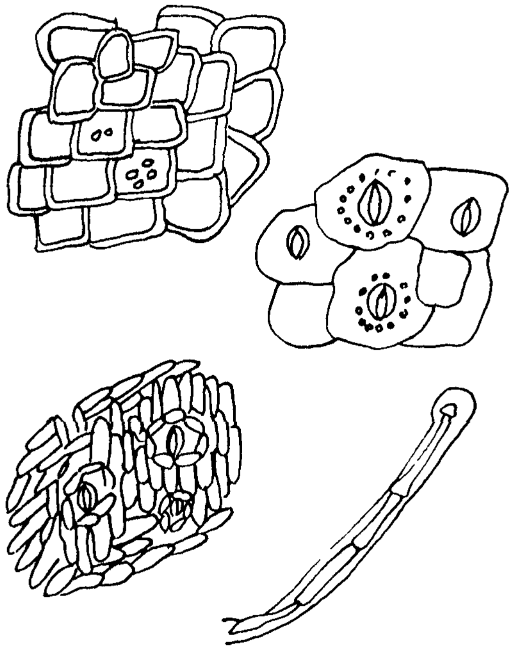
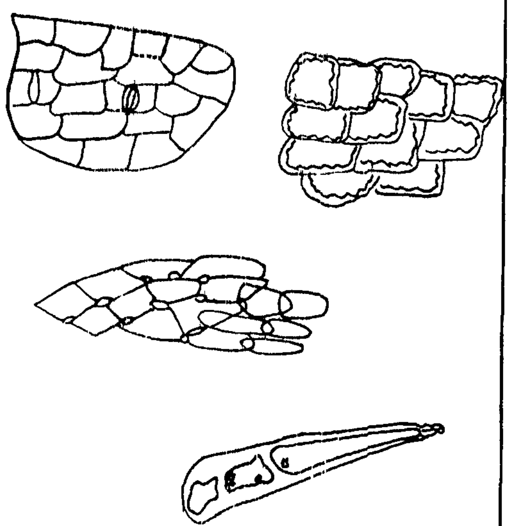


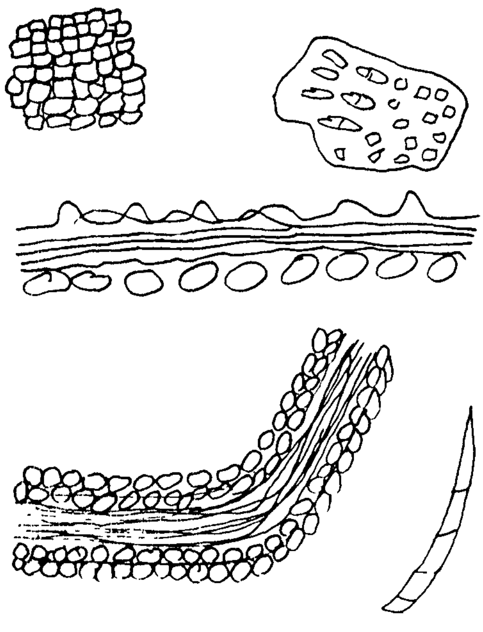
PROSOPIS JULIFLORA



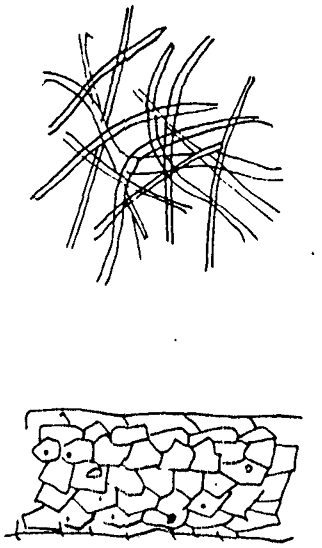
CAPPARIS SEPIARIA



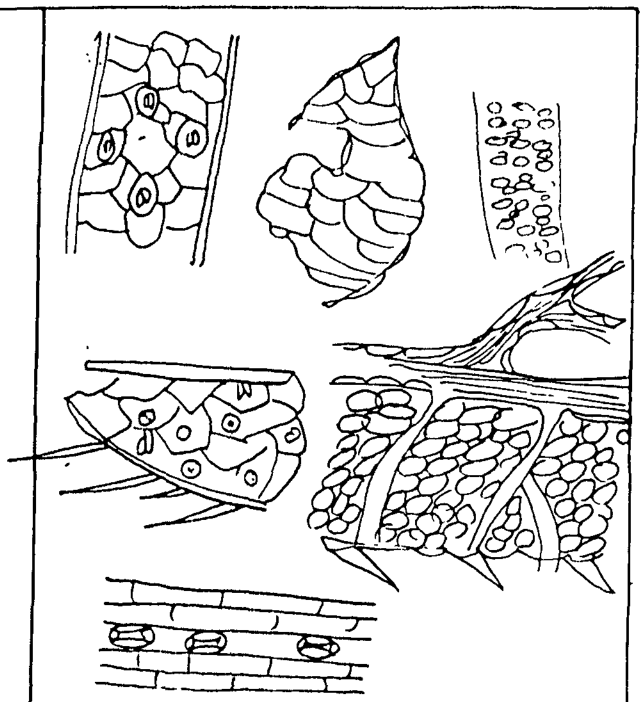
PROSOPIS SPICIGERA



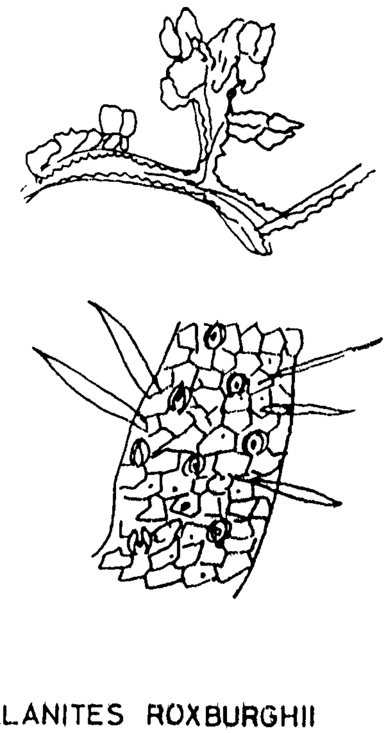
KIRGENELIA RETICULATA



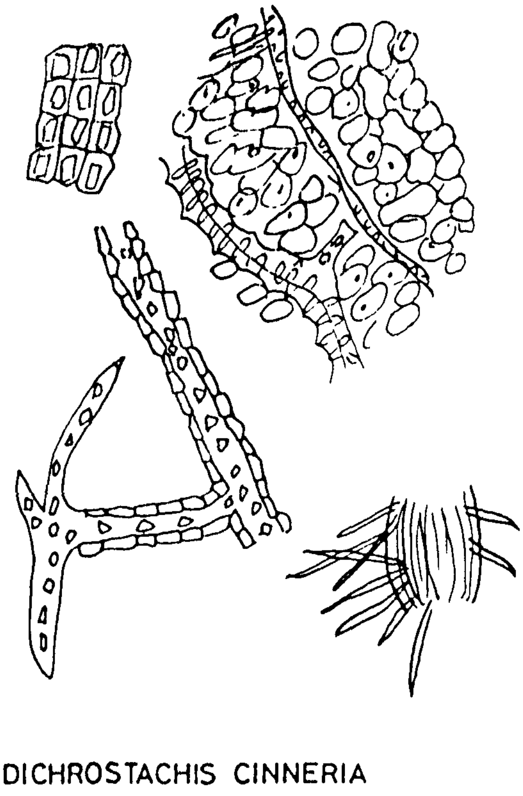
ZIZYPHUS MAURITIANA



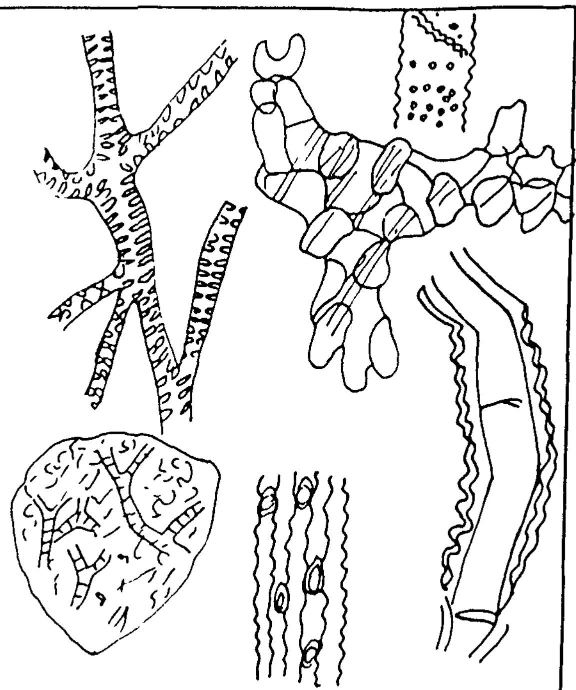
ACACIA LEUCOPHLOEA



BELANITES ROXBURGHII

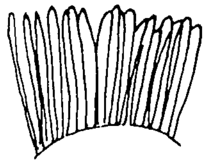


DICHROSTACHIS CINNERIA

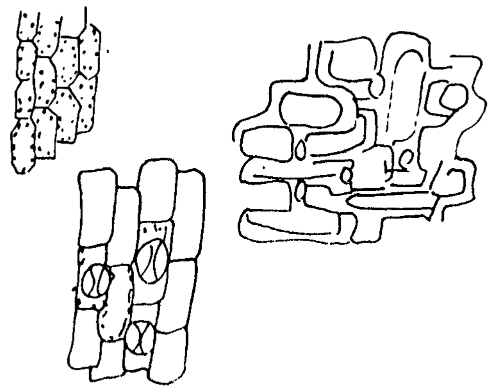


CASSIA TORA

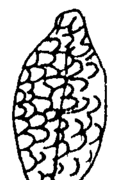
SALVADORA PERSICA (FRUIT)



ACACIA NILOTICA (POD)



CYPERU ALOPECUROIDES (LEAVES)



CYPERUS ALOPECUROIDES
(INFLORESCENCE)

PLATE 1

WETLAND DURING MONSOON AND WINTER

PLATE 2

DRIED UP WETLAND DURING SUMMER

PLATE 3

CHITAL KILLED BY STRAY DOG

PLATE 4

FERAL CATTLE BOGGED DOWN IN THE
SOFT SOIL OF MARSH HABITAT

PLATE 5

SAMBAR BROWSING AND GRAZING IN THE WETLAND

PLATE 6

NILGAI BROWSING IN THE WETLAND

PLATE 7

THE BREACHED BOUNDARY WALL OF THE PARK

PLATE 8

THE BROKEN WATERINLETS THROUGH THE BOUNDARY WALL

PLATE 9

A HERD OF FERAL CATTLE IN LOW GRASSLAND HABITAT

PLATE 10

THE MARSH AREA 'PLOUGHED' BY WILD BOAR